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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JANUARY 1920.

GENERAL PHYSICS.

1. *New Chronograph for Projectiles.* **P. E. Klopsteg** and **A. L. Loomis.** (Phys. Rev. 14. pp. 159–160, Aug., 1919. Abstract of paper read before the Am. Phys. Soc., April, 1919.)—The chief features of this chronograph are as follows: (1) A constant-speed d.c. motor with automatic governor. (2) A shallow cylindrical aluminium drum, mounted on the vertical shaft of the motor and taking a record strip of paper inside, on which a spark produces a bright blue spot. (3) Circuit arrangement by which the projectile causes a spark to record the instant at which its tip perforates a special contact target. E. H. B.

2. *Conversion of an Uneven to an Even Scale.* **A. Berger.** (Zeits. Instrumentenk. 39. pp. 252–255, Aug., 1919.)—In continuation of previous work by Krüss [see Abs. 362 (1919)] the author shows how any conversion formula of the type $y = f(x)$ can be dealt with in converting an uneven instrument scale to an even scale. The method depends on keeping a pointer accurately over the curve $y = f(x)$ by means of two sets of micrometer screws working simultaneously along the x and y axes. J. W. T. W.

3. *Graphical Method for Experimental Data.* **H. G. Schwerdt.** (Phys. Zeits. 20. pp. 362–368, Aug. 15, 1919.)—A method is described, with diagrams and typical examples, for determining graphically the mean value of or the best curve for a set of experimental data. The method is based on the "least square" principle. A. W.

4. *Perspective.* **K. Mack.** (Akad. Wiss. Wien, Ber. 127. 2a. pp. 699–717, 1918.)—Describes a new method, based on projective geometry, for obtaining perspective views of solids, and also gives details of an apparatus for producing perspective drawings. Numerous diagrams are given to illustrate the method and to show the construction of the apparatus. A. W.

5. *Legislation in France on Units.* **R. Poincaré.** (Rev. Gén. d'Él. 6. pp. 311–312, Sept. 6, 1919.)—Secondary units of many kinds are included

in legislation of April 2, 1919. Certain of the more novel features will be mentioned. The cubic metre of wood is a *stère*. In addition to the decimal system of sub-dividing a right angle, the English method of *degrees, minutes* and *seconds* is adopted. The *carat* for measuring precious stones is 0·2 gm. The *sthène* is a force which in one second gives a speed of 1 m./sec. to one tonne (which is the mass of a cubic metre of water). The *pièze* is that uniform pressure which if exerted over a square metre produces a total effort of 1 sthène. The *thermie* is a unit of heat which raises 1 tonne of water 1 deg. The *grande-calorie* and the *petite-calorie* are respectively 1/100th and 1/1,000,000th of 1 thermie. The unit of light-flux, a *lumen*, falls in one second on a square metre on the surface of a sphere of 1 m., if a very small source of one *bougie decimale* be placed at the centre of the sphere. The *lux* is the illumination on a surface of 1 square metre, receiving uniformly a flux of 1 lumen. A *phot* is an illumination equal to 10,000 lux. The *mille marin* and *nœud* correspond exactly to the English nautical mile and knot. The *kilogramme-poids* is the force with which 1 kg. is pulled to the earth. The unit of energy is a *kilogramme-metre* (kg.-m.). The *cheval-vapeur* is a power corresponding to 75 kg.-m. per sec. The *poncelet* is a power equal to 100 kg.-m. per sec. P. E. S.

6. *Brinell and Scratch Tests for Hardened Steel.* **R. A. Hadfield** and **S. A. Main.** (Inst. Mech. Eng., J. No. 7. pp. 581–586, Oct., 1919.)—The Brinell test is unsatisfactory when applied to hardened steel, owing to the deformation of the ball. This note describes a modified form of scratch test, the apparatus consisting of a balanced-lever arm, fitted with jockey-weight, carrying at its end a diamond point. The diamond is drawn along the polished specimen under a weight of 6 oz. and the width of the scratch is measured. From the results obtained it appears that the scratch hardness bears the following relation to the Brinell hardness: Brinell hardness = 0·02675/(width of scratch in mm.)^3. This formula must be regarded as quite tentative and empirical, since the establishment of a satisfactory and rational hardness scale for the scratch method will involve further work. **W. C. Unwin.** (Engineering, 108. p. 669, Nov. 21, 1919).—Unwin points out that the most novel feature of these tests is that for very hard steel the scratch-hardness number is much greater than the Brinell number. This depends on the assumption that $H_s = 0{\cdot}02675/w^3$, where w is the width of the scratch in millimetres. There is some reason for thinking that scratch hardness varies inversely as the square and not as the cube of w, and Hadfield's results are fairly well represented by the expression $H_s = 0{\cdot}622/w^2$. The interest of the scratch test is chiefly its application to the harder steels, and the errors of the scratch test are probably greatest in the most ductile material. Taking the 24 hardest steels of Hadfield's series, the expression which fits the results best is $H_s = 0{\cdot}68/w^2$.

It seems a reasonable assumption that scratch hardness is proportional to the work expended on removing unit volume of material; that the work expended is proportional to Pl, where P is the load and l the length of the scratch; and the volume removed is klw^2, where k is a constant depending on the form of the diamond point. Hence the work expended per cubic unit is proportional to $H_s = BP/w^2$, where B is a constant for a given diamond point. Martens defined scratch hardness as the load required to produce a scratch of a given width. But if w is constant, H_2 is proportional to P in accordance with Martens' definition. If P is constant as in Hadfield's tests, H_2 varies inversely as w^2. C. O. B.

7. *Ball Hardness of Work-hardened Copper and Brass.* **A. Portevin.** (Rév. de Mét. 16. pp. 235–238, July–Aug., 1919.)—Gives the ball-hardness figures of electrolytic copper, 90–10 brass and 67–33 brass, with a 10-mm. ball under a pressure of 500 kg. for 30 secs., and with a 3·18-mm. ball, under a pressure of 30 kg. for 30 secs. The specimens were examined as received and after various reductions by rolling in the cold state; the reductions ranged from 5 to 300 % in the case of copper, 10 to 250 in the case of the 90/10 brass and 10 to 150 in the case of the 67/33 brass. C. O. B.

8. *Fatigue Phenomena in Metals.* (Am. Soc. Mech. Eng., J. 41. pp. 731–738, Sept., 1919.)—Consists of a progress report of the Committee on Fatigue Phenomena in Metals for the American National Research Council and summarises the available facts and theories relating to fatigue failure. Brief descriptions are given of the machines used for testing fatigue strength, the influence of localised stress in producing fatigue is discussed and also the relation between microscopic structure and fatigue. A number of special subjects related to fatigue which are needing investigation are mentioned. C. O. B.

9. *Further Experiments on Stress Determination in Flat Steel Plates.* **J. Montgomerie.** (Inst. Naval Architects, Trans. 61. pp. 281–289; Disc. and Corres., 289–297, 1919. Engineering, 107. pp. 786–790, June 13, 1919.)—The object of the experiments was to obtain accurate information with regard to the conditions of stress and strain existing in mild-steel plates firmly fixed at the edges and exposed to uniform hydraulic pressure over their unsupported surfaces. Working along lines analogous to those described in a paper read before the Institution of Naval Architects in 1917, the author has determined the principal stresses and inclination of principal axes of strain in plates of various thicknesses, subjected to water pressures of 10, 20, 30 and 40 lb. per sq. in. The general conclusions as regards the effect of the results on shipbuilding practice are: (1) that the stress in plating due to water pressure is not so great as had been assumed and under the same conditions of loading is not of the same order of magnitude as the stress developed in the stiffeners; (2) that, given stiffeners of efficient design, the plating of watertight bulkheads and all types of structure intended primarily to resist water pressure, might with safety, from the strength point of view, be reduced in thickness; and (3) that the increase in thickness of the shell plating of steam vessels in respect of wider frame spacing provides for substantially the same stress conditions under the new conditions as in the standard vessel (see p. 41 of Report of Committee appointed by Board of Trade to advise on load lines of Merchant Ships). F. C. A. H. L.

10. *Flexure of Cantilevers of Unsymmetrical Section.* **M[ary] Seegar** and **K. Pearson.** (Roy. Soc., Proc. 96. pp. 211–232, Oct. 9, 1919.)—A treatment of the problem of applying de Saint-Venant's solution to the flexure of a cantilever of cross-section possessing a single axis of symmetry which may be either perpendicular to or in the plane of loading.

The latter case is the one treated in the paper, for a section of "trough" or "gutter-pipe" form, represented by a curtate circular annulus loaded in its plane of symmetry. The paper is mainly mathematical, and cannot be usefully abstracted. J. W. T. W

11. *Stresses in Thin Shells of Circular Section.* **F. K. T. v. Iterson.** (Engineering, 105. pp. 640–642, Nov. 14, 1919.)—Discusses the stresses in thin-walled bodies subjected to bending moments, from the theory of thin-walled vessels supporting internal pressure. Examples of the use of such vessels, constructed of steel plates, for the storage of gases or liquids are given, and the application of a form of great strength, possessing curvature in two directions, to the design of ferro-concrete cooling towers for the Dutch State collieries is described and illustrated. J. W. T. W.

12. *Calculation of Strength of Riveted Girders.* **P. Fillunger.** (Akad. Wiss. Wien, Ber. 127. 2a. pp. 1987–2051, 1918.)—Shows that the ordinary method of finding the strength of a riveted girder is theoretically unsound, because the action of the rivets is not to produce a homogeneous girder of the same section, but one in which the individual rivets play their part and for which the effect of the rivet holes on the strength of the component parts cannot be neglected. A new treatment of the problem is given in the paper, using the relation $N = \alpha\epsilon$, where ϵ is the strain due to stress N, and α is a coefficient determined experimentally for a beam pierced with rivet holes. J. W. T. W.

13. *Percussion Figures in Isotropic Solids.* **C. V. Raman.** (Nature, 104. pp. 113–114, Oct. 9, 1919.)—This article includes photographs which illustrate the manner in which an isotropic solid breaks down under the stresses set up by impact when these exceed the limits of perfect recovery, and have a bearing on the theory of the collision of elastic solids developed mathematically by Hertz. The three figures in question show from three different points of view the effects produced on the surface of a thick glass plate by the impact of a polished hard-steel ball. It is thus shown that the cracks which occur originate at the *margin* of the compressed area. It seems clear that the internal fracture practically occurs along the surface of max. *shearing* stress set up during the impact. **J. W. French.** (*Ibid.* 104. pp. 312–314, Nov. 20, 1919.)—French puts forward as supplementary to the above a number of observations made some time ago as to what really happens when a glass surface is being ground. The paper is illustrated by ten figures and should be consulted in the original. E. H. B.

14. *Electrical Nature of the Cohesive Forces of Solid Bodies.* **M. Born.** (Deutsch. Phys. Gesell., Verh. 21. pp. 533–538, Aug. 30, 1919.)—The author and A. Landé have previously shown [see Abs. 528 (1919)] that the elastic compressibility of the halogen salts of monovalent metals and of fluorspar may be explained on the assumption that the ions attract or repel corresponding to their charges according to the Coulomb law, and that, in addition, between any two ions there exists a force of repulsion whose potential is inversely proportional to the ninth power of the distance. In the present paper some further constants of the salts are calculated according to the same method, viz., based on the frequency

of the long-wave ultra-red absorption, and the elasticity constant. The paper is mathematical throughout, and the results obtained support the hypothesis that the cohesion of heteropolar crystals depends upon electrical forces. H. H. Ho.

15. *Displacement from Vertical in Free Fall.* **W. C. Baker.** (Phys. Rev. 14. pp. 352–355, Oct., 1919.)—A method of obtaining the displacement from the vertical, due to the earth's rotation, of a body falling freely from a given height. It is shown that an appreciable difference in the result is obtained according as the trajectory is treated as a parabola or ellipse, the respective expressions being in the ratio of 3 to 2. J. W. T. W.

16. *Rotating Projectiles from Smooth-bore Guns.* **C. G. Abbot.** (Nat. Acad. Sci., Proc. 5. pp. 386–388, Sept., 1919.)—At the rear of the elongated projectile are a number of quasi-tangential chambers, each provided with a propellant which is ignited by priming contained in the tangential apertures. The projectile is thus spun and so kept steady in its path. E. H. B.

17. *Theory of Friction in Liquids.* II. **J. D. van der Waals, Jr.** (K. Akad. Amsterdam, Proc. 21. 10. pp. 1283–1293, 1919.)—A continuation of earlier work [Abs. 676 (1919)]. The present paper deals successively with (i) the distribution of density in a liquid flowing in a field of force; (ii) the distribution of density in a flowing liquid at the critical point; (iii) the application of the virial relation; (iv) the stress tensor in a flowing liquid. A. W.

18. *Analysis of Forces due to Oblique Air Streams.* **H. Haedicke.** (Zeits. Vereines Deutsch Ing. 63. pp. 983–985, Oct. 4, 1919.)—Discusses the results obtained by existing theories of air pressure on an inclined plane, and the effect of eddies on the windward and leeward sides of the plane. J. W. T. W.

19. *Stream-line Flow from a Disturbed Area.* **A. R. Richardson.** (Phil. Mag. 38. pp. 433–452, Oct., 1919.)—The view put forward in this paper is that solutions of the type considered may be used to indicate where existing motions may be expected to break down; to suggest where viscosity will cause vortices to form; and to enable an estimate to be made of the effect of alteration in shape on the resistance of a body moving at a given speed. E. H. B.

20. *On the Theory of Turbulence.* **L. Hopf.** (Ann. d. Physik, 59. 6. pp. 538–582, Aug. 22, 1919.)—In every kind of liquid flow the transition from the laminar to the turbulent state, when certain limiting values are exceeded, has not yet received theoretical explanation. Osborne Reynolds has shown experimentally that a certain value R exists known as the "Reynold number," below which the laminar stream exists, and above which turbulence takes place, namely: $R = \sigma vl/\mu$, where σ is the density, μ the viscosity coefficient, v the velocity, and l a given length of stream. This sudden transition at the critical value from laminar flow to turbulence has not yet been theoretically accounted for. In a previous investigation [Abs. 1189 (1914)], the author has applied the

method of small oscillations to this problem without, however, obtaining the desired result, absolute stability being found at every Reynold number. The usual procedure was here adopted of taking the flow between a fixed and moving wall as the fundamental flow, whereby the velocity distribution normal to the direction of the stream follows a linear law.

The present paper contains a critical examination of all possible disturbances. Section 2 deals with the mathematical formulation of the problem, and section 3 with the derivation of the transcendental equation. Section 4 considers the limiting case for static liquid, and section 5 with further limiting cases. Sections 6 and 7 contain the calculations of the critical numbers. Section 8 examines higher oscillations, and section 9 forced oscillations. It is shown that absolute stability of the main flow occurs at a smaller Reynold number, and instability at a higher one, when the spatial frequency a of the disturbance does not exceed a limiting value of $a = 2 \cdot 4$; *i.e.* instability towards disturbances of greater wave-lengths. The critical Reynold number depends on a, and is lower the smaller a is; the minimum value being 11. The behaviour of the stream lines is as follows: With a smaller Reynold number there exists a system of oscillations as in the static liquid, containing a fundamental and its harmonics. With a larger Reynold number the oscillations behave exactly as in a frictionless liquid, except that in a boundary layer the motion deviates with increase in the number, while fulfilling the boundary conditions. With large Reynold numbers the paradoxical result occurs, that the disturbing influence grows stronger under certain circumstances in a viscous than in a frictionless liquid, although it can never render the viscous stream unstable without having the same effect on the frictionless liquid. H. H. Ho.

21. *On the Problem of the Jet of Falling Liquid.* **R. Scheuermann.** (Ann. d. Physik, 60. 3. pp. 233–259, Oct. 20, 1919.)—Previous investigations on the shape of a liquid jet by Newton, Weisbach, Helmholtz, Kirchhoff, Lang, and Rayleigh, are first referred to in Section A. Section B deals primarily with the shape of the falling liquid jet. The equation is evolved for the meridian curve of the jet, taking gravity into account. Following this comes an investigation into the effect of surface tension on the form of the jet, and the curvative relations of the jet surface, after which the equation is derived for the form of the jet when gravity and surface tension are both taken into account. Experiments are next very fully described, and comparison tables are given for the experimental and calculated results. Section C investigates the dissolution of the jet into drops. Capillary waves on liquid jets are first studied, and an equation for them is derived. Ahrendt's work is next referred to, this being based on a combination of the Thomson law with the Torricelli formula, whereby λh is a constant, λ being the wave-length and h the height. The latter is shown to be valid only when the wave-lengths are small compared with the circumference of the jet, otherwise λh is shown to be a function of the wave-length and of the radius of the jet. An experimental investigation of the law then follows, this being photographically illustrated and accompanied by a table of results. Confirmation has been afforded to a certain degree for Rayleigh's theory on the instability of liquid jets. The section concludes with an application of these results to Buff's view of fluid-jet dissolution, in which the wave-like swellings which take place at the lower part of the jet, and

which may be rendered visible, are held to promote the disintegration of the jet. A photographic illustration is given. The swellings have no special propagation velocity, but must use the stream itself for transport purposes, and are shown to be due not to the oscillations of the jet, as Buff assumed, but to the jet opening itself. H. H. Ho.

22. *Resistance to Motion in Viscous Media.* **A. Lechner.** (Akad. Wiss. Wien, Ber. 127. 2a. pp. 1629–1642, 1918.)—This paper contains as its chief problem the calculation of the resistance encountered by a spherical body during progressive motion within and on the surface of viscous media, based on the theory of viscous fluids. This calculation involves the integral expression for the thermal effect produced by motion in a viscous medium. The mathematical treatment for the motion of a viscous medium is shown to be analogous to that employed by Hertz for the solution of a problem in elasticity. The work has further involved a general hypothesis for the vortex motion of viscous fluids, and also an analogy between the heat produced in a viscous medium and the influence on a magnetic field of an electrically charged sphere. Section I contains the fundamental equations; II, the integration of the equations of motion; III, a supplement to the Helmholtz hypothesis on vortex motion; IV, the motion and energy loss of a sphere; V, an electrokinetic analogy; VI, the resistance of a hemisphere; VII, the resistance of a sphere at any given depth of penetration.

The paper is mathematical throughout.

H. H. Ho.

23. *Nutation of Unsymmetrical Gyroscope.* **R. Grammel.** (Phys. Zeits. 20. pp. 398–400, Sept. 1, 1919.)—Discusses the problem mathematically, and includes five figures showing double and triple loops and still higher complexities involving four and five-fold loops, concluding with a ten-looped case. E. H. B.

24. *Gravitation.* **L. Majorana.** (Comptes Rendus, 169. pp. 719–721, Oct. 27, 1919.)—The author previously put forward (Oct., 1919) the hypothesis of a possible absorption of the Newtonian attraction by the masses traversed and found that the experimental index should be of the order 10^{-12}. Using lead for the attracting bodies and mercury as the interposed medium, the author has now experimentally evaluated the coefficient in question. Thus he writes $m_a = m_v e^{-hrd}$, where m_a is the apparent mass of the lead, m_v its true mass, h the coefficient of absorption per unit density, d the density of the mercury, $r = 8{\cdot}4$ cm. The author thus finds that $h = 6{\cdot}18 \times 10^{-12}$, which is in striking agreement with the value predicted. E. H. B.

25. *On H. Weyl's Theories of Gravitation and Electricity.* **W. Pauli, Jr.** (Phys. Zeits. 20. pp. 457–467, Oct. 15, 1919.)—Weyl has recently published a paper [Abs. 908 (1918)], which contains an extension to the ordinary theory of relativity based on a generalisation of the Riemann geometry. The present author first gives a sketch of Weyl's work, and then proceeds to investigate its physical consequences. The geometrical side has been fairly well developed already. Section I deals with the necessary mathematics. Section II then considers the universal function. In Section III the gravitational field equations are developed. Section IV investigates static centric-symmetrical fields, and considers the electronic problem. No contradiction is found to be involved with the perihelion motion of Mercury. The universe as a closed system follows from the theory, as also the electrical, matter-free, four-dimensional world of constant curvature as a solution of the field equations. The laws with respect to positive and negative electricity, however, are found to be symmetrical in a static field, a circumstance which is a great, if not insuperable, difficulty for Weyl's theory. H. H. Ho.

26. *Experimental Proof of the Change in Weight which a moving Body undergoes upon a Normally Shaped Earth Surface in an Easterly or Westerly Direction as a consequence of its Motion.* **R. Eötvös.** (Ann. d. Physik, 598. pp. 743–752, Sept. 19, 1919.)—A postulate of the Galileo-Newtonian mechanics is that a body moving east decreases in weight, and increases in weight when moving west. The magnitude of this gravity acceleration is given by $\Delta g = -2\Omega \cos \varphi . dy/dt$, where Ω is the angular velocity of the earth, φ the geographical latitude, and dy/dt the velocity in a rectangular coordinate system whose axes are the celestial north, east, and perpendicular to these. A direct experimental proof was, however, only afforded less than a quarter of a century ago. Hecker's data obtained during voyages in 1901 on the Atlantic Ocean and on the Indian Ocean in 1904–1905 are first discussed, and then a further series on the Black Sea in 1908. Section 2 of the paper deals with the possibility of obtaining data in the laboratory, and discusses the resonance method. Section 3 gives the dimensions of the max. deviation to be acquired by resonance, and Section 4 the method by which it may be observed and measured. Section 5 describes the compensation method. Several illustrative diagrams are given. H. H. Ho.

27. *Atomic Orientation.* **T. R. Merton.** (Phil. Mag. 38. pp. 463–464, Oct., 1919.)—In modern theories of the structure of the atom the supposed arrangement is of such a kind that the atom may be described as having an axis perpendicular to the plane in which an electron (or a ring or rings of electrons) is in rotation. Since it is well established that the atoms in a crystal are arranged in a perfectly regular manner, it is of interest to inquire whether the axes of these atoms are also oriented in a regular manner, or whether their directions are distributed at random. Assuming the former condition to be more probable, and that the direction of ejection of α- and β-particles from a radio-active atom is also related to the orientation of the atomic axis, the author has made experiments with crystals of uranium nitrate, to test the theory. The result is entirely negative, the radio-activity of the crystals examined being independent of the face from which the α-rays were emitted.

A. B. W.

28. *The Mutual Disturbances of Electronic Rings in the Atom, and the Explanation of Röntgen Spectra.* **A. Smekal.** (Akad. Wiss. Wien, Ber. 127. 2a. pp. 1229–1252, 1918.)—According to the Bohr atomic model the assumption is justified, at least for the simplest case of the hydrogen atom, of obtaining a complete explanation of Röntgen spectra, especially as the experimental material from the outset showed a profound connection between this phenomenon and the number of the element in the periodic system. As a consequence of the latter relationship, the presence of the K-series of the Röntgen spectra is held to be bound up with the innermost electronic ring of the atom (K-ring), and, therefore, the absorption and emission phenomena attached to the K-series must be associated with this particular ring. The absorption process, which produces the emission of the K-lines, is generally held to be identical with the removal of an electron from the K-ring, and is supported by much experimental data. Two different views are held concerning the mechanism of emission. The older assumption of Kossel is that an electron passes from the K-ring to one of the outer electronic rings and returns, whereby the normal state of the atom is restored, so that emission is merely a question of electronic re-arrangement by which the number of electronic rings remains unchanged. Debye, however, assumes that the electron before emission describes an orbit, in accordance with quanta conditions, which is external to the K-ring but does not coincide with any of the other electronic rings. This conception was worked out by Debye, the K-ring being regarded as monoquantic and the starting orbit of K_a as diquantic.

The present author now discusses Debye's theory, pointing out that deviations therefrom are to be expected, inasmuch as no consideration has been given by Debye to disturbances caused by external electrons, while his formula has only been amended by empirical terms to include deviations. The study of the mutual disturbances of the electronic rings is now undertaken with the object of improving the Debye formula for K_a. The question is examined as to whether the rings are coplanar or not. According to S. Meyer a disc representation is possible for paramagnetic elements, which, however, Reiche and the author have denied, at least when no further charges are assumed in the region of the L-ring. The paper itself is entirely mathematical, and contains very comprehensive tables of data. The author concludes by asking how we can hope to understand the absorption and emission of electromagnetic radiation so long as the atomic model is founded solely upon electrostatic forces. H. H. Ho.

29. *Relation between Wind and Distribution of Pressure.* **H. Jeffreys.** (Roy. Soc., Proc. **96**. pp. 233–249, Oct. 9, 1919.)—Taylor has shown that provided atmospheric turbulence is the same at all heights, and the system is steady, the surface wind velocity S is equal to G $(\cos a - \sin a)$, where G = geostrophic wind and a = deviation of the surface wind from the isobars. From observations taken over the North Sea the correlation between these two quantities is found to be about 0·5 in place of the 1·0 of perfect concordance. It is somewhat less than the correlation between the surface and geostrophic winds. The smallness of the above correlation may be attributed to either (*a*) great variation in turbulence with height contrary to Taylor's assumption, or (*b*) irregularities in the isobars, which render difficult the correct determination of G and a. In order to test the second hypothesis a longer series of ships' observations was employed. Frequency curves plotted for a show marked asymmetry of a definite type, and for this and other reasons it is concluded that the suggestion (*b*) above will not account for the facts. The conclusion is thus reached that turbulence may not be regarded as being independent of height, and the author proceeds to treat mathematically the case where turbulence is a function of height. For illustrative purposes the relation k (turbulence coefficient) $= k_0 \times (1 + \lambda z)^2$ is taken, and a connection between surface and geostrophic wind of the form $S/G = \cos a$

$-h \sin a$ is deduced. This provides more elasticity than Taylor's corresponding equation, and allows of values of a greater than 45°. As turbulence in the upper strata is closely connected with vertical motion and thus with certain types of cloud, there is some reason to anticipate a correlation between cloud form and q, but little indication of such correlation is found. J. S. Di.

30. *Tornadoes in Eastern Nebraska.* **G. A. Loveland.** (Monthly Weather Rev. 47. pp. 234–236; Disc., 236, April, 1919.)—Three tornadoes occurred in Eastern Nebraska within an area of low pressure on the evening of April 6, 1919. A notable feature of the conditions lay in the distribution of temperature, two stations less than 200 miles apart recording 46° F. and 76° F. respectively at 6 p.m. Photographs of one of the tornadoes are reproduced and show that the funnel, which was only 100 to 300 ft. in diameter, became very sinuous. As the top and bottom of the funnel travelled in slightly different directions, the core became drawn out in length and the diameter contracted, and finally disintegration occurred. J. S. Di.

31. *Incidence of Fog in London, Jan.* 31, 1918. **C. E. P. Brooks.** (Meteorolog. Office, Professional Notes No. 3. [10 pp.], 1918.)—A map showing the intensity of the fog which occurred over parts of London during the evening of Jan. 31, 1918, indicates that the max. density was found in the Thames Valley up-stream from Fulham and in the tributary valleys of the Beverley Brook and River Wandle to the south. In some districts the intensity was quite exceptional. On the slope of the hill which culminates as Wimbledon Common the cessation of the fog was abrupt, while on the other hand in the north of London the diminution in fog intensity was very gradual. Upper-air observations show that above the light surface wind a breeze of from 10 to 20 miles/hr. from about S. prevailed, while the presence of a temperature inversion over London is inferred. The fog appears to have been a typical radiation fog of anticyclonic weather. Under the influence of light surface easterly breezes the cold, fog-laden air drifted slowly up the Thames Valley, keeping to the low ground. J. S. Di.

32. *The Inter-relation of Wind Direction and Cloud Amount at Richmond.* **D. Brunt.** (Meteorolog. Office, Professional Notes No. 1 [11 pp.], 1918.) —Observations at Kew Observatory extending over the 15 years 1899–1913 for 10 h., 16 h. and 22 h. were used in the analysis. The months are treated separately, and the amount of cloud is noted under the 8 main wind directions and under calms. An outstanding feature is the number of cases of clear sky at 22 h. compared with the other hours dealt with. The frequency of cloud amounts 0 and 1 (tenths covered) at 22 h. is three times as great as at either of the other hours during the summer, and twice as great during the winter. Another feature of interest is the relative infrequency in winter of half-covered skies at night. At this season winds having a west component are on the whole less cloudy than those having an east component, and they show a much stronger tendency to clear skies at night. Large diurnal changes of cloud are also found with east winds during Aug. and with SW. winds from July to October. Similar tables computed for Greenwich exhibit the same general features as those for Richmond. J. S. Di.

33. *Characteristics of the Free Atmosphere.* **W. H. Dines.** (Meteorolog. Office, Geophys. Mem. No. 13. [32 pp.], 1919.)—The paper summarises present knowledge of the free atmosphere up to a height of 20 km. above the surface. Tables show mean temperature at different heights for different parts of the world, and the change in conditions with change of latitude is discussed. For the British Isles and certain other regions the seasonal range is also considered. A max. value of the annual temperature range occurs at about 7 km. With a coastal climate the range at this level exceeds that at the surface, but this is not so with a continental climate. Between 9 km. and 12 km. the range falls off rapidly. There is a small lag in phase from the surface up to about 11 km., but above this the time of minimum temperature falls back rapidly to the beginning of Jan. at 13 km. over Europe. The diurnal range of temperature is discussed. It is found that this, in its surface form, practically ceases between 1 and 2 km. Records of humidity show that over Europe in summer the water contents of the atmosphere are equivalent to about 20 mm. of rain, and in winter to 10 mm. A table shows the mean height of the base of the stratosphere for different places with the amplitude of the annual variation.

Pressure differences between place and place do not exhibit much change between 2 and 10 km. height. Above 12 km. they fall off rapidly, until at 20 km. the pressure seems to be uniform over all those parts of the earth where observations have been systematically made. A table of correlation coefficients exhibits the connection which exists between the different elements in the free atmosphere. The various means by which cooling of the air in the centre of depressions and warming in the centre of anticyclones can come about are discussed. It is demonstrated that the observed effects can be accounted for by adiabatic changes connected with air rising or falling through moderate heights in the two systems. With regard to the height of the base of the stratosphere it is shown that this height is regulated by the pressure at about 9 km. above the surface. Regression equations connecting the different quantities demonstrate that so far as Europe is concerned water-vapour plays a very small part in the larger mechanics of the atmosphere and that its amount has but a trifling effect, if any, on the thickness of the troposphere. In an appendix to the paper the standard deviations of pressure, temperature and density at different heights over England S.E. are given. At levels between 3 and 6 km. the variation of density hardly exceeds 1% of the mean value. J. S. Di.

34. *Air Routes to Australia.* **G. Taylor.** (Monthly Weather Rev. 47. pp. 78–80, Feb., 1919.)—Consideration of the geographical distribution of land and sea areas leads to the conclusion that the main aerial route to Australia will be *via* India and the Straits Settlements. The prevailing winds on this route are discussed and attention is directed to the advantage of flying at different levels according to the direction of travel; *e.g.* an aviator flying north-westward from Australia in July would fly at a low level in the SE. trades, while in the opposite direction he would fly at a greater altitude in the poleward return current above the trades.

J. S. Di.

35. *Flight of Aircraft and Deflective Influence of the Earth's Rotation.* **C. F. Marvin.** (Monthly Weather Rev. 47. pp. 75–77, Feb., 1919.)—

An aeroplane moving over the earth is subjected to a continuous tendency to turn to the right in the northern hemisphere due to the earth's rotation. If other causes of deflection from the compass course may be regarded as haphazard and it be assumed that the course is corrected only at stated intervals of time, this deviation will lead to an error in making the objective, which is here calculated. If the course is set every minute the error will amount to about 5 km. on a ten hours' run at 90 miles/hr. in latitude 50°. If the course is rectified every n minutes instead of every minute the error will be approximately $5 \times n$ km. J. S. Di.

36. *The Diurnal Variation of Wind Velocity in the Free Air.* **J. Rouch.** (Comptes Rendus, 169. pp. 293–295, Aug. 11, 1919.)—At the surface, mean wind velocity has a maximum in the afternoon and a minimum in the early morning; at the top of the Eiffel Tower (300 m.) the max. velocity occurs, on the other hand, shortly after midnight. An analysis of pilot-balloon ascents made at different times of day shows that above 300 m. the wind velocity during the early morning remains greater than that during the afternoon up to about 2000 m., where the difference becomes very small. The difference remains small up to 3000 m., and it can thus be concluded that, in general, there is no diurnal variation of wind velocity between 2 and 3 km. So far as the observations go, it would appear that from 3 to 6 km., the max. wind occurs in the afternoon hours again, as at the surface. R. C.

37. *The Variation of Wind Velocity with Height.* **E. H. Chapman.** (Meteorolog. Office, Professional Notes No. 6, pp. 62–79, 1919.)—The author finds that the variation of wind velocity with height in individual cases is too irregular to be expressed by a mathematical formula. On the other hand, if the mean law of variation is obtained by combining a number of results of pilot-balloon ascents either collectively, or assorted according to different classifications, it appears that a formula of the type: $V = a \log H + b$, where V is wind velocity, H is height, and a and b are constants, can be chosen to fit the mean values very well from 50 to 500 m. above the ground. The constants a and b vary from group to group, and from place to place. Above 500 m. the formula does not hold good. R. C.

38. *The Mechanics of Free Balloons.* **F. Jentzsch-Gräfe.** (Phys. Zeits. 20. pp. 320–328, July 15, 1919.)—Only large military balloons or airships capable of lifting considerable masses are considered, and the volume of hydrogen contained is supposed to remain constant. The chief results attained are: (*a*) The diminution in the rate of ascent, the max. height attained, and other related matters can be expressed in terms of a single variable p, called the specific rising-value, which is the free lift per unit of mass. (*b*) The rate of ascent and the height at any moment, also the duration of the ascent, can be expressed in terms of p, and the initial velocity of ascent. (*c*) The exact influence of change of temperature is worked out mathematically.

The results were obtained and verified experimentally at Ostende in the summer of 1915, and subsequently used for military purposes. R. C.

39. *The Rate of Ascent of Pilot Balloons.* **J. Rouch.** (Comptes Rendus, 169. pp. 83–85, July 15, 1919.)—Balloon ascents watched through one theodolite to determine the wind currents aloft are based upon the assumptions that the rate of ascent is constant, and is a function of the weight of the balloon and the free lift.

Experiments were made to test these assumptions, and for this purpose 168 ascents were made, and the balloons were followed with two theodolites. The balloons weighed 50 gm. each, and a free lift of 150 gm. was given to them by inflation with hydrogen. The mean observed rate of ascent was 188 m. per min., and a detailed classification of the rates of ascent of each balloon up to 10 km. shows that at hardly any point above 1 km. does the observed rate differ from the mean by more than 20 %, and that, in the great majority of cases, the observed rate is within 10 % of the mean rate. Vertical currents are most prevalent during the middle of the day, but their effects do not extend beyond 800 m., so that the one-theodolite method can be relied on above that height.

The formula giving rate of ascent in metres per min. (V) in terms of the weight of balloon (W) and the free lift (L), both expressed in gm., given by J. S. Dines is $V=84L^{1/2}/(W+L)^{1/3}$, the form of which can be deduced theoretically on the hypothesis that in the steady state the ascensional force is balanced by the air-resistance, assumed to be proportional to the square of the radius of the balloon. The constant of the formula was determined from observations of small balloons weighing less than 20 gm. This constant would need to be altered from 84 to about 120 to suit the results obtained with larger balloons weighing from 50 to 90 gm., but the author suggests a new formula for the larger balloons, $V=42L/(W+L)^{2/3}$, which would require that the air-resistance be assumed proportional to the radius of the balloon. This is said not to be unreasonable with the low velocities in question. R. C.

40. *Measurement of Water in Clouds.* **L. F. Richardson.** (Roy. Soc., Proc. 96. pp. 19–31, Aug. 1, 1919.)—Measurement of the water contents can be made with two types of cloud: (1) those through which the sun's outline can be seen and which also exhibit coronæ; and (2) uniform stratus, provided that some means can be found of measuring the size of the water particles. In the case of clouds through which the sun can be seen shining the edge of the disc if observed through dark spectacles almost invariably appears quite sharp. It is the contrast of illumination at the edge which is measured by a simple and readily portable instrument, here described. In order to arrive at an equation connecting this contrast of light with the water contents of the cloud any thin layer of cloud is regarded as a sieve, so that the fraction of the incident light which comes straight through depends only on the size and number of the holes in the sieve, and thus on the size and number of the water-drops. The scattered light which reaches the instrument is superposed upon the disc and its surroundings alike and therefore does not affect the contrast measured and can be neglected. A very simple equation results connecting the water-content with the diminution of the contrast at the sun's edge, but the diameter of the particles enters in and must therefore be determined from consideration of coronæ or otherwise. In the case of the thinnest cirrus which produces a just sensible dimming of the sunlight the mass of ice per horizontal cm.^{2} is calculated to be $0{\cdot}22 \times 10^{-3}$ gm., and with high stratus through which the sun's disc is just discernable $0{\cdot}9 \times 10^{-3}$ gm.

For thick stratus through which the sun is not visible another apparatus is described, devised to measure the illumination from the cloud. An equation is deduced which connects this with B the reflectivity of the ground and with $\int C.dh$, where C is the fraction of the radiation which has its vertical component reversed in sign by the scattering in unit length of ray (the integral to be taken through the vertical thickness of the cloud). The former (B) has been determined under different conditions and values are here given. $\int C.dh$ evidently is dependent upon the water-content of the cloud. In order to deduce the connection the distribution of the light which strikes a single drop is considered in detail. A measurement made with the apparatus on strato-nimbus from which rain fell led to the result that the volume of liquid per horizontal cm.^{2} of cloud may amount to 24 diams. of the cloud droplets. This figure is greater, as it should be, than the largest number of diameters, namely 4, determined by the first method for a stratus which just allowed the sun's disc to be seen. J. S. Di.

41. *Upper-Air Temperatures at Martlesham Heath.* **W. F. Stacey.** (Meteorolog. Office, Professional Notes No. 4. [20 pp.] 1919.)—During the period March, 1917, to January, 1918, temperature records (373 in number) were obtained on 191 days. The ascents ranged up to 5 km., or in a few cases 6 km., height and mostly took place between 6h and 20h., *i.e.* during the daytime. Temperatures above 1·5 km. are found to be largely dependent upon barometric pressure, a connection which has already been established by *ballon-sonde* observations. Consideration of the changes of temperature from day to day leads to the suggestion that more regular and better distributed observations of temperature up to 5 km. height might assist in determining the path that the centre of a depression will follow. The range of temperature at different levels in each of the months covered by the observations shows that the max. range is generally found between 4 and 5 km. The mean range up to 5 km. varied from 9 deg. C. in August to 20 deg. C. in Jan. The diurnal change of temperature found on certain occasions leads to the conclusion that radiation ceases to be effective at quite a small height above the ground, but that there is a layer of the atmosphere a little above this height in which terrestrial radiation is effective and which forms a minor radiating surface, this being the layer of the lower clouds. Inversions of temperature in the first 5 km. height are found to be on the average about 0·5 km. thick, but an extreme thickness of 1·35 km. is recorded. J. S. Di.

42. *Possible Improvements in Weather Forecasting, with special reference to the United States.* **V. Bjerknes.** (Monthly Weather Rev. 47. pp. 99–100, Feb., 1919.)—Recommends the drawing of lines of air-flow for purposes of daily forecasting and points out that additional telegraphic reporting stations would be required above the number at present in use. It would not be necessary that these stations should have complete instrumental equipment. Observations of direction and strength of the wind and of temperature, with reports on the state of the sky with special reference to distant clouds or rain, would suffice. J. S. Di.

43. *Direction of Rotation of Cyclonic Depressions.* **J. S. Dines.** (Monthly Weather Rev. 47. p. 87; Disc., 87–89, Feb., 1919.)—The

gradient wind equation is a quadratic in "V," so that two roots for velocity satisfy the equation. It is pointed out that one of these corresponds with normal counter-clockwise rotation for a cyclone in the northern hemisphere and the other with reversed or clockwise cyclonic rotation. Both forms of rotation appear theoretically possible. The clockwise rotation would be the more rapid under similar conditions of pressure gradient and curvature. In a small whirl of the tornado type the "curvature" term in the gradient wind equation would outweigh the "geostrophic" term and velocity in this case would be almost the same in either direction. It seems not impossible that tornadoes may occasionally rotate in the clockwise direction and observers of such phenomena are asked to make careful note of the direction of rotation of the whirl. In the *discussion* **C. F. Brooks** worked out a numerical case and added diagrams showing the accelerations involved. **C. F. Marvin** considered the effect of the earth's rotation on right- and left-hand turns of aeroplanes. In the northern hemisphere an aeroplane can turn through a given angle to the right with less loss of height than in a similar turn to the left.

J. S. DI.

44. *Some Observed Irregular Vertical Movements of Pilot Balloons.* **I. R. Tannehill.** (Monthly Weather Rev. 47. pp. 223–225, April, 1919.) —Among notable departures from the normal rate of rising of balloons a case is cited where a balloon rose at 396 m./min. for 5 minutes before passing into a cumulus cloud, in place of a normal rate of 193 m./min. as deduced from formula. The effect of errors of this nature in the assumed rate of rising is discussed with special reference to an ascent on a particular occasion when the computed balloon track just before entering an a-cu. cloud sheet was much distorted from the true wind movement as shown by the clouds. On this occasion a second balloon liberated half an hour after the first gave similar indications of a vertical current.

J. S. DI.

45. *Some Scientific Aspects of the Meteorological Work of the United States Army.* **R. A. Millikan.** (Monthly Weather Rev. 47. pp. 210–215, April, 1919. Paper read before the Am. Phys. Soc., April, 1919, at Washington.)—Within a year of the inception of the Meteorological Service of the United States Army 37 pilot balloon stations had been established in the United States and 20 with the army abroad. 500 men were trained for the work. In the United States 5000 double-theodolite pilot balloon ascents were made in one year, and from these the following formula for the rate of ascent of balloons was empirically determined, namely: $V = 71 (l/L^{2/3})^{5/8}$, where V = rising velocity in metres per min., l = free lift, and L = total lift, in gm. The two theodolite ascents showed that the rate of rising of the balloons was practically constant up to the greatest height reached, the slight increase in rate which would be expected with decreasing air density being counteracted by slow diffusion of gas through the rubber.

Artillery fire at objects the position of which on the map is known but which are hidden from view has been much developed during the war. This has necessitated consideration of varying wind and density effects aloft. Range tables taking account of wind and density have been constructed by co-operation between the meteorological service and the Ordnance Department. For propaganda work an automatic device was developed for dropping ballast from balloons and thus controlling their height and prolonging their flight. Experimental flights up to 1100 miles in length were obtained by this means. Charts of the winds at different levels over the United States were prepared at Washington daily. J. S. Di.

46. *The Military Meteorological Service in the United States during the War.* **B. J. Sherry** and **A. T. Waterman.** (Monthly Weather Rev. 47. pp. 215–222, April, 1919.)—Points touched on in the previous paper [preceding Abs.] are further developed. Simultaneous pilot-balloon ascents made at two stations 25 miles apart showed that the wind at the same level above the two stations seldom differed by more than 4 % at altitudes over 1000 metres. Consideration of vertical currents in the atmosphere showed that in the daytime in the first 400 m. of ascent the rate of rising of balloons is likely to be about 20 % above normal. It is often diminished for the succeeding 100 m., after which it becomes constant. Strong isolated ascending and descending currents may at times be found at heights up to 10 km. For night work with pilot balloons a small candle lantern was found to be the most satisfactory source of light. An ingenious wholly graphical method of computing winds from single-theodolite pilot balloon ascents is described and illustrated. J. S. Di.

47. *Transatlantic Flight from the Meteorologist's Point of View.* **W. R. Gregg.** (Monthly Weather Rev. 47. pp. 65–75, Feb., 1919.)—Weather conditions along the routes Newfoundland to Ireland and Newfoundland to Portugal *via* the Azores are discussed. Mean conditions are first dealt with and then consideration is devoted to the part a meteorologist should play on the occasion of an individual flight. As regards surface conditions temperatures of −25° C. and −5° C. have been recorded at St. John's and Valencia respectively, but frost has never been reported at the Azores or Lisbon, on the southern route. The average cloudiness throughout the year along the northern route is about 70 %, but in this are included records of fog which is logged as overcast sky. The southern route is less cloudy. To south-east and east of Newfoundland fog occurs upon about 60 % of all days in summer and upon from 20 to 35 % in winter. The fog is shallow, seldom extending above 300 m. and, further, it is mainly confined to the sea and does not generally extend far inland. On the northern route gales occur on about 25 % of all days in winter and on 5 % in summer. From Newfoundland to the Azores the figures are 20 % and 3 % and from the Azores to Portugal 7 % and 1 % in winter and summer respectively. Data concerning upper-air conditions over the ocean are scanty and the conclusions put forward are of necessity based largely on inference. With regard to occasions of individual flights it is recommended that observation ships fitted with wireless be posted along the course; weather reports on surface and upper-air conditions would be sent out by these. Wireless reports should also be furnished by regular shipping so that synoptic charts could be prepared for the North Atlantic, and the existing wind calculated from the isobars. The wind expected in the next 12 or 24 hours could also be forecasted. Marine synoptic charts covering a period of 10 years have been scrutinised and the occasions counted when wind conditions were excellent, good, fair, or poor for the eastward and for the westward journeys on both northern and southern routes. The more

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favourable conditions for the eastward as compared with the westward journey are strikingly shown. J. S. Di.

48. *Rigidity of the Earth.* **A. A. Michelson** and **H. G. Gale.** (Nature, 104. p. 114, Oct. 9, 1919.)—A previous experiment gave the ratios of the amplitudes of tides observed in N.-S. and E.-W. pipes to the amplitudes computed for the same pipes on the assumption of a perfectly rigid earth as 0·523 and 0·710 respectively. New observations with automatic recorder give 0·69 for both E.-W. and N.-S. ratios. It has been found that an error had been made in the computations in the previous work. [See Abs. 1038 (1914).] E. H. B.

49. *Electrodynamic Method of Investigating the Earth's Crust.* **H. Löwy.** (Phys. Zeits. 20. pp. 416–420, Sept. 15, 1919.)—Describes experiments carried out in South-West Africa by H. Kröncke, who used the "capacity and damping" method of Löwy, and also Leimbach's "quarter wave-length" method for attempting to estimate the depth of the reflecting surface. [See Abs. 1162 (1912).]

It was found that the antenna used could be laid on the ground without insulation. The capacity measurements show marked differences at different places. Decrease of the capacity, due to elevation on hills or to increased distance from a spring, was observed; while at different places with the same depth of the underground water the capacity was found to have the same values. The investigations indicated the existence of five underground streams, with indications of their direction (obtained by the capacity method) and estimations of their depth (by the quarter wave-length method). A. W.

50. *Structure of the Earth's Crust.* **B. Willis.** (Nat. Acad. Sci., Proc. 5. pp. 377–383, Sept., 1919. Abstract of paper read before the Am. Geolog. Soc.)—From an early stage in the growth of the earth onward the lighter and heavier masses of the crust have tended towards an equilibrium in isostatic adjustment. It is conceivable that at some time the departure from the equilibrium may have been such that the stresses set up in the crust were adequate to cause flow and mass movement, until a close approach to isostatic equilibrium was attained. But the present departure from equilibrium is not of such a magnitude, nor is it likely that there has been such a departure since the complete cooling of the earth's crust, *i.e.* since the commencement of geological time. Nevertheless, the effort towards isostatic equilibrium produces non-uniform stresses which are long enduring and persistent in direction. In any mass which is lighter than its environment the direction of least stress would be vertically upward, and the direction of greatest stress would be horizontal; and *vice versa.* If the lighter and heavier masses be in elastic continuity with one another, the upward stress in the former and the vertical stress in the latter would combine to form a resultant which would curve from below upward. Thus the zone embracing the adjacent parts of both columns would be subject to a curved stress, which would proceed outward and upward from the heavier mass. Since rocks recrystallising under stress have their foliation in the direction of least stress, the resulting foliation should be orientated in a curve corresponding to the curve of stress of isostatic inequilibrium. The foliation should be horizontal under the heavy element, vertical at the

lighter element, and curve upward in between. The heavier portions will thus be discoidal with a lower surface convex downwards. The intermediate lighter portions will have a sort of truncated triangle as their vertical cross-section, and they may be called interdiscs. The crust will, therefore, exhibit three structural types superficially: (*a*) The surfaces of the heavy discs, depressed by gravitative adjustment and more or less deeply covered with water, with an underlying high density. (*b*) The surfaces of the light interdiscs covered with the sediments of shallow seas, or exhibiting approximately vertical foliation where denuded down to the metamorphic rocks. (*c*) The marginal zones of the discs and interdiscs characterised by igneous intrusion and orogenic disturbances. W. A. R.

51. *Earthquake Wave Propagation.* **C. G. Knott.** (Roy. Soc. Edinburgh, Proc. 39. pp. 157–208, 1918–1919.)—For the first time the forms of the seismic rays and of isochronous surfaces have been deduced directly from observations by a rigorous mathematical method. The seismic rays of both types are concave outwards, indicating that the speeds of propagation increase with depth, until a depth equal to about three-tenths of the earth's radius is reached. At this depth the speeds of propagation tend to a constant value, and fall off slightly at greater depths, whilst certain waves show a convexity outwards. The observations are insufficient to trace waves which reach greater depths than six-tenths of the earth's radius. At, or near, this depth the distortional wave is killed out, so that over actual distances from the epicentre greater than 120° there is no characteristic appearance of the secondary wave in the seismograms. The hypothesis suggested is that the earth consists of an elastic solid shell down to a depth of about half the radius; that at this depth the rigidity begins to break down; and that at a depth of about six-tenths of the radius the elastic solid shell gives place to a non-rigid nucleus of measurable compressibility. H. Jeffreys' suggestion that the phenomena may be co-ordinated in terms of the theory of firmo-viscosity is worthy of consideration, although there are difficulties to surmount. W. A. R.

52. *Structure of the Sun's Radiation.* **P. H. van Cittert.** (K. Akad. Amsterdam, Proc. 22. 1. pp. 73–81, 1919.)—The intensity of sunlight falls off towards the limb, and not equally for all wave-lengths, as the limb is more red than the centre. The author assumes only that the sun can be regarded as a glowing gaseous body with temperature and density diminishing outwards from the centre, its outer layers being gas-masses of comparatively low luminosity and absorption but of great diffusive and irregularly diffractive power. The region 6000 λ to 4000 λ presents an irregularity in the nature of an oscillation in the intensity curve, and the author accounts for this by considering the way in which the effect of the deeper layers increases from the centre to a maximum, and falls off rapidly when near the limb. W. W. B.

53. *Heliographic Latitude of Solar Prominences,* 1880–1918. **A. Riccò.** (Comptes Rendus, 169. pp. 574–578, Sept. 29, 1919.)—Sun-spot and prominence data 1880 to 1890 from Palermo, and since then sun-spot data from Greenwich, and prominence data from Catania, have now accumulated for more than three complete 11-year sun-spot periods.

The author's tables and curves show that there is a general resemblance between the run of latitude of the spots and that of the prominences, but the latitude of the latter is always from 15° to 30° greater, the sun-spots rarely reaching a latitude higher than 35°, while the prominences sometimes extend as far as the poles. The prominences reach their minimum latitude shortly after their max. frequency, and their max. latitude near minimum frequency, agreeing with the law of Carrington and Spörer for the latitude of sun-spots. It is noted that spots are observed on the disc and prominences on the limb, so that the epoch of observation is not quite the same. The three periods, 1880–1890, 1891–1901, and 1902–1912, agree quite well in the mean latitude of prominences and in the definite, though small, preponderance of prominences in the Southern hemisphere. The author attributes some of the differences between the two sets of curves to the inclusion of quiescent hydrogen prominences in the sun's polar regions, with the more important eruptive metallic prominences in the equatorial regions which agree more closely with the sun-spot curve. W. W. B.

54. *Effective Temperature of the Sun.* **H. Groot.** (K. Akad. Amsterdam, Proc. 22. 1. pp. 89–96, 1919.)—Criticises an article by Defant on "Diffusion and Absorption in the Sun's Atmosphere," pointing out a numerical error that vitiates the argument, and objecting to the assumption that all kinds of light come to us from one photospheric surface, *i.e.* from the same depth of the sun.

The author finds on the whole a decrease of indicated effective temperature with increase of wave-length studied; and points out that this is the opposite of what might be expected from Planck's formula, but postpones the discussion of the cause of this apparent anomaly. W. W. B.

55. *Sun-spot Curve.* **S. B. Nicholson.** (Astron. Soc. Pacific, Pub. Aug., 1919. Nature, 104. p. 160, Oct. 23, 1919. Abstract.)—This curve is constructed to show the number of spots only, and takes no account of their area. It shows the maximum in Sept. 1917; the previous one, lower and flatter, in May 1905; with the intervening minimum in June 1913. Curves of mean latitude show in the present cycle a much steeper fall in latitude than in the preceding one. The author likens the spot-curve to that of Cepheid variables, and suggests that possibly pulsation is still going on inside the sun though not at the surface. W. W. B.

56. *Precise determination of Times of Contact in Solar Eclipses.* **R. Innes.** (Union Observat. of S. Africa, Circ. 45. pp. 4–5, June 13, 1919).—The author recognises the difficulty of observing an eclipse contact with a "boiling" sun's limb, and suggests a series of observations of chords of contact by projection on a white sheet or, preferably, ruled paper, so that the time of regular increments in the chord could be noted. The square of the chord varies as the time elapsed since first contact, or the time to elapse before last contact, and a graphic solution will give very accurate contact times. The method was evolved too late to be tried at the last eclipse. W. W. B.

57. *Theory of Jupiter's Satellites. I. The Intermediary Orbit.* **W. de Sitter.** (K. Akad. Amsterdam, Proc. 21. 9. pp. 1156–1163, 1919.)—

The theory outlined in a previous paper [Abs. 1049 (1918)] is elaborated in the present paper, but full details are reserved for the Leiden Observatory Annals. Some important simplifications result from a careful choice of units, that of time for instance being 1·1221899034 mean solar days. The perturbations of the satellites by each other and by the ellipticity of the planet are considered in the computation of the "intermediate orbit," from which the actual motions only differ by small terms of intermittent importance which can be applied as corrections. W. W. B.

58. *Longitude of Hyperion's Pericentre and the Mass of Titan.* **J. Woltjer, Jr.** (K. Akad. Amsterdam, Proc. 21. 6 and 7. pp. 881–892, 1919).—The author obtains for the mass of Titan from the mean motion of the argument of the libration the value $M/m^1 = 4080$. This is compared with the values computed by Eichelberger and Samter (4172 ± 58, 4125 respectively) from the perturbations of Hyperion. Thus the agreement is satisfactory. L. H. W.

59. *Perturbations of Hyperion depending directly on Titan's Eccentricity.* **J. Woltjer, Jr.** (K. Akad. Amsterdam, Proc. 21. 9. pp. 1164–1175, 1919.)—The effect stated by H. Struve from observation, which may amount to half a degree, is here computed in series involving powers of μ (perturbative function). From the period of libration $\mu^2 = 1/3986$ and from the motion of the pericentre $\mu^2 = 1/4080$. Taking the mean value of $1/\mu^2$ this gives $\mu^2 = 1/4033$ or $\mu = 0{\cdot}0157$. The effect is tabulated for the different elements and it is noted that the only large coefficient in that of the eccentricity is in good accordance (+0·0248 against +0·0230) with H. Struve's value from observation [see preceding Abs.]. W. W. B.

60. *Discovery and Elements of Comets* 1919 *b and* 1919 *c.* **Metcalf.** (Astron. J. 32. p. 104, Sept. 19, 1919.)—J. H. Metcalf discovered comets on Aug. 20 and Aug. 22. Jeffers gives the elements for the first, while Miss Heger gives those for the second. Leuschner identifies the first with Comet 1847 V. W. W. B.

61. *Two rapidly moving Stars in Pisces.* **F. Schlesinger.** (Astron. J. 32. pp. 108–109, Oct. 24, 1919.)—Van Maanen's 12th mag. star with annual P.M. of 3″ is only 14′ distant from a star of 6th mag. with P.M. 1·4″ and Wolf thinks they are physically connected. Allegheny determinations of parallax, however, give for the brighter star 0·15″ ± 0·008″ and for Van Maanen's 0·27″ ± 0·012,″ so that the idea of a physical connection must be abandoned. W. W. B.

62. *Probable Errors of Proper Motions in Polar Coordinates.* **F. Schlesinger.** (Astron. J. 32. p. 99, Sept. 19, 1919.)—The author gives a graphic method of showing the probable errors in distance and position angle in terms of those of right ascension and declination. W. W. B.

63. *Progressive Spectra of Nova Aquilæ* 1918–19. **A. L. Cortie.** (Observatory, No. 544. pp. 366–367, Oct., 1919.) [See also Abs. 1177 and 1371 (1919).]—This is a general sketch of the changes in the spectrum between June 10 and Oct. 23, 1918, and in July and Aug. 1919. F-type in the early stages, it became almost entirely A-type by June 15, this being towards the end of July so faint as to be masked by a brightening B-type, chiefly He lines. After Aug. 23, predominantly a planetary nebula with the B-type lines (He, O, N) remaining till Oct. 23, and at least one A-type group (Ti). The author thinks the nebula was present all the time, and that a solar eruption on a large scale in a giant star enclosed in a dark nebula is the explanation of the outburst. All the later developments from the B-type onwards he attributes to the nebula indicated. W. W. B.

64. *Preliminary Parallax and Magnitudes of Nova Aquilæ 3.* **C. P. Olivier.** (Astron. J. 32. pp. 100–102, Sept. 19, 1919.)—The writer is convinced that nobody in Europe could possibly have discovered the Nova so early as June 7, a matter about which claims have been made. Parallax plates taken at Harvard College Observatory give a preliminary value of 0·009" for the parallax, or a distance of about 360 light-years. This value may be modified by later plates whose accuracy will be increased as the Nova decreases in brightness. His own estimates of magnitude are given from June 8 to July 9, and those of other observers extending to Aug. 13. W. W. B.

65. *Stellar Distribution down to 11th Magnitude.* **H. Nort.** (Roy. Astron. Soc., M.N. 79. pp. 637–639, Oct., 1919.)—This paper traverses a previous one by Pannekoek [see Abs. 713 (1919)] in which the present author's results were discredited, as founded on data which were not homogeneous. He explains the steps taken to make the data (Henie's star-counts) homogeneous, and complains that Pannekoek has used the inferior parts of the plates (the corners) to obtain corrections for the centres. He considers that his work [Abs. 35 (1919)] was partly in error as to the densities, especially in the corners of the fields, but that Pannekoek has by his modifications spread the errors over all the stars and made the result worse instead of better. W. W. B.

66. *Cause of Cepheid Variation.* II. **C. D. Perrine.** (Astrophys. J. 50. pp. 81–106, Sept., 1919.)—The author gives his reasons for supporting the hypothesis that the cause of Cepheid variation is not pulsation but orbital motion. Among Cepheids for which orbits have been determined, those whose secondaries are relatively large show humps in their light-curves. Among 16 such, only two have eccentricities less than 0·13, the mean of the 14 being 0·30. Cepheids generally are eccentric, as shown by their light-curves. Among 41 stars with periods less than 17 days whose orbits are known, all but one have small eccentricities if their light-variation is small. Among 79 stars with periods from 17 days to 200 years only three have eccentricities smaller than 0·15 and only one smaller than 0·1. This sharply defined lower limit of 0·15 to the eccentricities is well marked among all periods above 15 days. The orbital eccentricities of binary stars appear to depend on the masses and separation of the components. Among short-period variables fainter stars show greater variation than brighter ones. Cepheids with the greatest variation are those whose orbital velocity is greatest. There is a tendency among short-period variables for those whose period is greater than 10 days to have rather larger light-variations, this being an abrupt and not a gradual change. For 16 Cepheids spectrographic orbits are available. These show evidence of a dependence of light-change on orbital eccentricity. Cepheid variation appears

to require the simultaneous satisfaction of several conditions. The author states these in order: (1) short periods and small orbital dimensions; (2) considerable orbital eccentricity; (3) relatively small size of primary; (4) preference for galactic regions; (5) small proper motion; (6) strong preference for F and G type of spectrum; (7) small light-range.

He discusses the relative importance of these conditions, and favours the suggestion of R. H. Curtiss that the best explanation is a resisting medium which enhances the brightness of the advancing face of the primary, in preference to other suggestions by J. C. Duncan and Loud, but emphasises the importance of increasing the number of spectrographic orbits of Cepheids, especially those with very small or very large eccentricities. W. W. B.

67. *Pulsation Theory of Cepheids tested by Residual Radial Velocities.* **C. D. Perrine.** (Astrophys. J. 50. pp. 148–150, Sept., 1919.)—This is an extension of the paper dealt with in the preceding Abstract. An increase in available data to 21 stars suggests a more careful examination to see whether the hypothesis of orbital motion shows a negative excess, as it should do if pulsation were the true cause of the variation of radial velocity. Omitting R R Lyræ, whose velocity is 50 km., the mean velocity is − 2 km. (or 10·4 km. regardless of sign). On a pulsation theory the velocity would be about − 16 km., but since − 2·0 km. is a great deal nearer the zero required for orbital motion than to the − 16 km. for pulsation, the author considers the evidence strong against pulsation, and concludes with suggestions for minimising the weight of other objections to the orbital hypothesis. W. W. B.

68. *A Remarkable Cluster of Stars.* **J. E. de Vos van Steenwijk.** (Observatory, 42. p. 315, Aug., 1919.)—Of 25,700 spectra in the first part of the new Draper Catalogue (⅙ of sky), 23 are marked peculiar, having narrow lines, and of these 20, belonging to classes B_2 to A_2, are between galactic latitudes +4° and − 5° and longitudes 54° to 60°; 14 being contained within 20 square degrees (gal. lat. − 1° to − 5° and long. 54° to 59°). A list of the stars is given with details of magnitudes and proper motion. W. W. B.

69. *RR Vulpeculæ; evidence of Darkening toward the Limb.* **M. Maggini.** (Astrophys. J. 50. pp. 141–147, Sept., 1919.)—This is an eclipsing binary with period about 5 days, and the author analyses 252 observations to determine the elements of the system. He proves the eclipses to be total, the fainter star, with only 30% of the combined brightness, totally eclipsing the brighter star, which has a diam. not quite half that of its companion. He finds the observed light-curve fit less closely with one computed on the hypothesis of a uniform illumination than with one assuming atmospheric absorption, causing darkening towards the limb; hence he concludes that the latter gives the true condition. He then computes the dimensions and other elements of the system on that assumption, obtaining by Shapley's method a hypothetical parallax of 0·00316. W. W. B.

70. *Colours and Magnitudes of Stellar Clusters.* XIV. *Further remarks on the Structure of the Galactic System.* **H. Shapley** and **M. B. Shapley.** (Astrophys. J. 50. pp. 107–140, Sept., 1919.)—Since globular clusters occur only outside galactic regions and open clusters are practically confined to those regions, the authors, assuming the open clusters to be nearer the sun, consider the mutual exclusiveness of the two classes a strong argument for a direct relationship between them. Within the past year, to the previously admitted 69 globular clusters 17 have been added, including some cases where prolonged exposure to the camera proved that clusters supposed to be open are in reality globular. Nearly all these are more than 100,000 light-years distant. The whole 86 clusters are next considered and the conclusions drawn that: (1) there is no sensible increase in the minimum distance from the galactic plane with increasing distance from the sun; (2) the provisional estimate of a distance of 20,000 parsecs to the centre of the system is not excessive, since the additional results have filled in gaps; (3) globular clusters seem to occupy a space like a split-wedge with base nearly through the sun and containing the great circle through galactic longitudes 55° and 235°, 43 being to the north and 43 to the south of the Milky Way plane. The absence of globular clusters in the galactic zone is shown not to be due to obscuring matter, since more distant clusters are not obscured; but this point has been disputed and is held over for another discussion. Examination not only of the homogeneous series of Franklin-Adams plates but also of the Harvard maps and Bailey's Milky Way photographs confirms the idea that globular clusters are of a fairly uniform size, and hence that there is a direct relation between parallax and diameter. The mean apparent magnitude of the 25 brightest stars in a cluster is also used as a criterion of distance, and the integrated light of the whole cluster should be equally satisfactory for this purpose.

Most of the globular clusters are rapidly approaching the sun, and so moving towards the galactic plane, while spiral nebulæ as a class are receding from the plane. Evidence is adduced that the galactic system moves towards longitude 105° (approx.) with a velocity of about 300 km. per sec. and the brighter spiral nebulæ recede with an average velocity of nearly 700 km.

Thus five conditions are stated which guide the authors in suggesting their cosmogony: (1) globular clusters nearly uniform in size; (2) complementary distribution of open and globular clusters; (3) existence of thousands of sub-organisations in galactic system; (4) contrasted distribution of spiral nebulæ and globular clusters; and (5) their opposed directions of preferential motion. They suggest that the disc-shaped galaxy has grown by accretion from globular clusters, but that spiral nebulæ are repelled by it; they also claim a rapid systematic motion for the galaxy itself.

The case of the B-stars is considered separately, especially the faint ones which are so little in evidence. The authors derive from this great flatness for the "local cluster," and that the faint B-stars are simply much more distant. They anticipate further evidence when the *Henry Draper Catalogue* is completed. **W. W. B.**

71. *The Blink Microscope.* **R. T. A. Innes.** (Scientia, Sept., 1919; Nature, 104. pp. 66–67, Sept. 18, 1919. Abstract.)—This is the best means of picking out the large proper motions on a pair of plates. Taking 5″ per century as the smallest P.M. to be detected on plates taken 25 years apart, the author says there are 3 such in every square degree, or 120,000 in the whole sky, and that with a century interval there would be 2 million P.M.'s.

These are not absolute, as they ignore the systematic drift due to the solar motion. Absolute places and P.M.'s of sufficient stars on each plate must still be obtained by the transit circle. W. W. B.

72. *Investigation of a Galactic Cloud in Aquila.* **A. Pannekoek.** (K. Akad, Amsterdam, Proc. 21. 10. pp. 1323–1337, 1919.)—In pursuance of a plan outlined some years ago [see Abs. 459 (1912)], counts of stars have been made on plates specially taken of the galactic cloud N.W. of γ Aquilæ, with centre near χ Aquilæ. One plate had exposures of 600, 600, 190, 60, 19, 6, and 2 secs.; another, of 1900, 1900 secs.; a third an exposure of 40 mins. with a grating over the N. half of the field; and the fourth, of 45 mins. with a grating over the S. half of the field. For comparison scale part of a photograph of Coma Berenices was used with exposures of 12, 15, 19, 24, 30, 38, 48, 60, 76, 95, and 120 seconds, giving 11 images of each star with successive 0·2 steps in magnitude. The faintest visible image on the first plate gives a guide to the faintest stars to be expected; and the author gives a considerable amount of space to a discussion of the variability of this limit. Five regions of equal area but different stellar density are marked out on the plate: and the figures (counts of stars) in the squares making up these regions are analysed. A conclusion is drawn that the influence of the galactic condensations is only perceptible after the 13·5 magnitude and that the absorbing dark nebulous mass causing the tripartite hole is so near as to dim the majority of the stars of the 10th and 11th magnitude, being simply interposed between us and the galactic background.

The author considers that very little has been gained in the counting of stars in photographs since the visual counts of Herschel. W. W. B.

73. *Graphic Method of predicting Occultations.* **D. M. Y. Sommerville.** (Roy. Astron. Soc., M.N. 79. pp. 605–613, Oct., 1919.)—An occultation of 7 Aquarii by Venus on March 2, 1918, suggested to the author a refinement of Bessel's method of predicting occultations, the new feature being the projection, on the fundamental plane through the earth's centre perpendicular to the line from the earth's centre to the star, of the meridians and parallels of the earth's surface, as well as the shadow of the occulting body. A set of charts being prepared for all latitudes from 0° to 30° (covering the possible zenith positions of the occulting body), the most appropriate one is selected for each particular case and the limiting circumstances are plotted on it with ease and surprising accuracy. Rules are given for finding the times of beginning and ending of the occultation at any station and for the construction on a stereographic chart of (1) the path of the centre of the shadow, (2) the line of simple contact, (3) the rising and setting curve, and (4) the curve of maximum in the horizon.

The occultation referred to was observed at the Lick Observatory on receipt of a cabled prediction from New Zealand, but the weather was unfavourable in New Zealand, and in any case no observation could have been obtained there further north than Christchurch. W. W. B.

74. *Apparent Changes in Spectrum of η Carinæ (η Argûs).* **F. E. Baxandall.** (Roy. Astron. Soc., M.N. 79. pp. 619–621, Oct., 1919.)—The writer draws attention to the differences between Miss Cannon's results from Harvard plates published in 1897, Gill's at the Cape published in 1901, and those of Moore and Sanford at Santiago in 1913. Of these the first only mentions dark lines, and three suggested explanations are given: (1) a real change before Gill's observation, (2) spaces between bright lines misinterpreted as dark lines at Harvard, and (3) the later exposures unsuitable for recording as faithfully as the Harvard ones. The author is inclined to the second suggestion, as no radical change is shown between 1899 [see next Abs.] and 1913, but attention is drawn to some minor variations, principally in relative intensity of lines in groups. Gill's spectrum is rather diffuse, and the bright bands crowded. The author desires series of spectrograms of the star with fairly high dispersion at intervals of a few years, as it is almost a unique star in type, representing a reversal of most of the strongest enhanced lines of α Cygni (Si and Mg notably excepted) with several conspicuous lines not yet identified with any terrestrial element. W. W. B.

75. *Spectrum of η Argûs.* **J. Lunt.** (Roy. Astron. Soc., M.N. 79. pp. 621–634, Oct., 1919.)—[See preceding Abs.] Having received the MS. of Baxandall's paper the author had spectrograms of η Argûs taken at the Cape in Feb. and April, 1919, with exposures of about 9 hours as against about 5½ hours at Santiago in 1913. He finds the spectra about the same as in 1913, and confirms the radial velocity of Moore and Sanford. A reproduction of the April 1919 plate is given and also a table of comparison of wave-lengths between the Santiago and the 1919 Cape photographs, with identifications, including some doubtful ones. The star appears to show H, Fe, and Cr, but lines agreeing with Ti, Y, V, La, Ca, Zr, Ce, Mn, Sr, Mg, Eu, Co, Ni, Cu, and Nd, are regarded as doubtful, and in fact unlikely. Reference is made to the peculiarities of the H-lines in the spectrum, and in view of the history of the star the author thinks it probable that a settling down of an extensive hydrogen atmosphere is taking place. The brightening of the star predicted by Loomis is overdue. Innes has announced the star to be double and suggests that past outbursts have been due to grazings at periastron, but the present author finds the radial velocity invariable, and agrees with the author of the previous paper in desiring periodical observations to look for changes in magnitude, radial velocity, or spectrum. W. W. B.

76. *Sources of Stellar Energy.* **H. N. Russell.** (Astron. Soc. Pacific, Publ., Aug., 1919. Nature, 104. p. 269, Nov. 6, 1919.)—Contraction being considered inadequate to maintain the output of energy for the enormous periods suggested by geology, the author concludes that there must be some source of internal energy inside giant stars that dies down before they become dwarfs. He thinks the temperature would be too low for this to come into action before the M-stage; but this stage, he says, is very short, and to this he attributes the failure to detect them in it. He applies the same hypothesis to overcome Eddington's difficulty [see next Abs.; also Nature, 104. p. 269, Nov. 6, 1919] about the maintenance of the pulsations of Cepheid variables, as the unknown force would make good from within the leakage of heat which would otherwise damp down the pulsations in a few thousand years. W. W. B.

77. *Sources of Stellar Energy.* **A. S. Eddington.** (Observatory, 42. pp. 371–376, Oct., 1919.)—This is a discussion of H. N. Russell's article [see preceding Abs.]. The energy of a star has generally been assumed to be due to shrinkage, but this can only account for comparatively short evolution periods; the discovery of radium having made far less difference than was expected. The new suggestion is that the energy expended in radiation comes from some unknown enormous store of energy within the star. Russell says it must generate large quantities of heat per unit mass inside the stars, but practically none inside the earth or in the laboratory. It must not accelerate its own rate so as to bring about explosive conditions, which are not common and are, even in the case of novæ, apparently superficial. It must be regulated to supply heat to each star at almost exactly the rate at which the star radiates heat to space. It must ultimately die down, to account for the "dwarf" stage, and yet must be able to last a very long time at that stage. These conditions point to an enormously high internal temperature. The author of this summary admits that this theory will account for the abrupt commencement of the spectral series with very bright, giant, M-stars and also for the pulsations of a Cepheid variable, but he is in doubt as to the large majority of stars that are not Cepheids. He then suggests that the source of energy might be the destruction of electrons by mutual annihilation, an idea which he thinks entails very great, but not insuperable, difficulties. His own previous investigations have been on the hypothesis of energy generated uniformly through the body of the star, so that the idea of its concentration in the hottest central region does not apply to the contraction theory which he had in view. He considers the new idea worth following up. W. W. B.

78. *Distance Correction for Harvard Sky-map Plates.* **H. Nort.** (K. Akad. Amsterdam, Proc. 21. 9. pp. 1213–1218, 1919.)—By distance correction is meant the necessary allowance for the fact that the limiting magnitude shown on a plate varies from the centre to the margin.

Assuming that differences of density outwards from the centre of a plate must be due to spherical aberration, the author was surprised to find that this difference varied with the star density. Dividing the 55 plates into three groups—those showing less than 20 stars per square degree; 20 to 35; and more than 35—he found a considerable difference between the first and third. Next eliminating the effect of the concentration of stars in the galaxy, he found a less, but still unmistakable, difference; this he thinks is attributable to colour, which will naturally affect spherical aberration, and also has some relation to the galactic condensation. He concludes that the plates should be divided into two classes, according to galactic latitude and not to mean density. His counts show that for plates outside the galaxy the limiting magnitude increases to a distance of about 16 mm. from the plate centre and decreases from there to the margin, while for galactic plates there is a more pronounced decrease, and this starts from the centre without any preliminary increase.

W. W. B.

79. *Precession and Prediction of Occultations of Stars by Planets.* **R. I[nnes].** (Union Observat. of S. Africa, Circ. 45. pp. 5–6, June 13, 1919.)—Planetary occultations of stars are rarely predicted, though of great interest and importance. The author attributes this to the awkwardness of allowing for precession in mapping the paths of the planets. To obviate this he proposes to use zodiacal maps along the Invariable Plane with longitudes measured from a fixed departure-point. He considers that too much attention is paid to precession, which is only required in general for transit-circle observations. W. W. B.

80. *Motion of a Gaseous "Anchor-Ring" in a Resisting Medium: Application to Planetary Envelopes of Uranus and Neptune.* **E. Belot.** (Comptes Rendus, 169. pp. 639–642, Oct. 13, 1919.)—A preceding note [Abs. 1012, (1919)] showed that in a resisting medium there can be an infinite number of spiral orbits in which gravitation balances the centrifugal force. Experiments made with smoke-rings increasing from 10 cm. to 25 cm. in diam. show how rapidly the rings increase in diam. when a plane surface is interposed in their path. The author compares his smoke-box with the sun and obtains equations giving a distance at which envelopes would be expected to roll up like smoke-rings. This distance he finds greater than that of Saturn and approximately equal to that of Uranus. He suggests that this explains the very small inclination of the axis of Uranus to the ecliptic. According to the theory the envelope of Neptune must also be rolled up into a sort of anchor-ring. W. W. B.

81. *Group of Helium Stars in Orion.* **O. Bergstrand.** (R. Soc. Scient. Upsala, Nova Acta [Ser. 4], 5. No. 2. Nature, 104. p. 299, Nov. 13, 1919. Abstract.)—This group is probably connected with the great nebula in Orion, so the author has endeavoured to derive the distance of the nebula by means of the parallaxes of the stars. First, he examined the proper motions to determine the rate of closing in on δ Orionis, finding parallax 0·0044″ ± 0·0049″. Next, from the scattering of individual P.M.'s he obtained 0·0076″ ± 0·002″. These are in fair accordance with each other and with Charlier's 0·0118″ and Kapteyn's 0·0058″. Four of the stars are binaries, and their mean hypothetical parallax, according to Hertzsprung and Stebbins, is 0·0078″. The plausible conclusion is that the distance of the nebula is about 400 light-years. W. W. B.

82. *Analysis of Magnitude Curves of Variables in Four Clusters.* **H. C. Plummer.** (Roy. Astron. Soc., M.N. 79. pp. 639–657, Oct., 1919.)—This paper deals with clusters ω Centauri, M3, M5 and M15, following Bailey's classification into groups (*a*), (*b*) and (*c*), of which (*a*) differs from (*b*) in having flatter maxima and quicker periods, the limiting period being about 16 hours. Class (*c*), the author thinks, are probably eclipsing binaries, their variation giving simple sine curves. The numbers are given:

Cluster.	(*a*) and (*b*).	(*c*).	Period > 1 d.	Total.
ω Centauri	56	34	5	95
M3	110	0	0	110
M5	61	8	3	72
M15	30	29	1	60
Total	257	71	9	337

Making the phase angle of the first harmonic 180° in every case, those of the second and third harmonics are plotted against each other in a diagram for each cluster according to Phillips' suggestion, and appear more or less grouped about a line $\varphi_2 - 0\cdot 6\varphi_3 = 90^\circ$ compared with Phillips' $\varphi_2 - 0\cdot 6\varphi_3 = 76^\circ$ for the long-period stars of Group II. A few stars which fit badly may very likely be in the foreground and not belonging to the clusters.

The coefficients for each star are tabulated separately for the four clusters in order of length of period, including two long-period variables in ω Centauri of 297 and 484 days respectively. W. W. B.

83. *New Nova.* **H. Shapley.** (Astron. Soc. Pacific, Publ., Aug., 1919. Nature, 104. p. 160, Oct. 23, 1919. Abstract.)—This was discovered by Wolf in 1917 and independently by Barnard this year. Place for 1917: R.A. 17h. 35m. 13·45s. S. Decl. 11° 53′ 57·6″. 11th photographic mag., F0 type, large positive radial velocity. No plates show it before 1909, and all since 1910 show it. The author suggests that either the star is just beginning its stellar career; or that it is an irregular variable like η Argûs; or that it has just emerged from behind an obscuring nebula. He has tested the third hypothesis by a long-exposure photograph with the 60-in. reflector, but the evidence is inconclusive. Joy finds by Adams's method a distance of 500 parsecs. W. W. B.

84. *New Nova.* **[Miss] Woods.** (Harvard Observat., Bull. No. 693. Nature, 104. p. 160, Oct. 23, 1919. Abstract.)—Position for 1875; R.A. 18h. 24m. 6·2s. S. Decl. 29° 20·9′. Formerly 14th mag. this nova rose to 11th mag. in 1901 for a time. On 24th April, 1919, it rose to 7th mag. and has now sunk to 12th and appears nebulous. Found on Harvard plates. W. W. B.

85. *Form of an Eclipse Chart near the Pole.* **D. M. Y. Sommerville.** (Roy. Astron. Soc., M.N. 79. pp. 613–618, Oct., 1919.)—When the rising and setting curve is of the distorted figure-of-eight type, the curve of maximum in the horizon does not in general pass through the node, in spite of the Nautical Almanac charts, and the present paper deals with the conditions for the existence of a node and of the meaning of the triangular region formed on the earth's surface. Dealing for simplicity with the case of an occultation of a star, the author shows how the triangle varies, an interesting case being when it bounds the region where a star is occulted before setting, but is so nearly circumpolar that it has risen again in time for the end of the occultation. W. W. B.

LIGHT.

86. *Portable Clinometer.* **C. Pulfrich.** (Zeits. Instrumentenk. 39. pp. 201–212, July, 1919.)—Describes a new form of clinometer shown in plan in Fig. 1 and in elevation in Fig. 2. P_1 is a silvered prism and P_2 a double-silvered 45° prism. P_3 is a prism for viewing the objects the angular distance of which it is desired to measure. As P_2 is rotated, the angle between the objects viewed is double the angle of rotation. The application of this instrument to the measurement of angular distances of various kinds is described and illustrated in the paper. J. W. T. W.

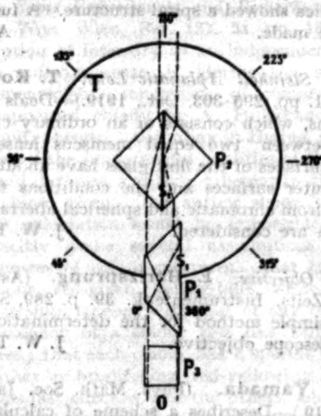

Fig. 1.

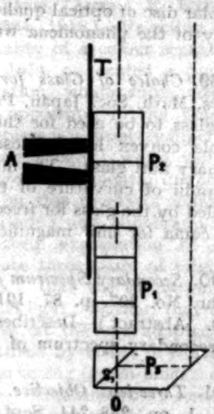

Fig. 2.

87. *Proofs of Elementary Theorems of Oblique Refraction.* **A. Everett.** (Phil. Mag. 38. pp. 480–483, Oct., 1919.)—In text-books on Geometrical Optics, the elementary theorems of oblique refraction (*i.e.* where the ray is not in the plane of the paper) at a single surface appear invariably to be proved by plane projectional methods. In discussions of the question of deviation by prisms, however, the method of projection on the sphere is generally adopted. The present paper gives alternative proofs of the three elementary theorems, using the method of spherical projection, and concludes with the first step in the discussion of prismatic deviation. A. W.

88. *Doubly Refracting Structure of Silica Glass.* **Rayleigh.** (Nature, 104. p. 153, Oct. 23, 1919.)—The author has observed that silica glass possesses a remarkable crystalline or quasi-crystalline structure when examined in the polariscope. The double refraction is extremely weak, the retardation being probably of the order of 1/1000th of a wave. The best arrangement found for observing the effect is to use a nicol as polariser, not a glass reflector, and to dispense with lenses between the nicols. A magnifying lens of 2-in. focus is placed above the analyser. An extremely bright light is necessary. The nicols are accurately crossed for extinction. If a circular plate of fused silica of "ordinary" quality with polished faces is examined in this arrangement, it shows a striking mosaic of dark and bright parts without regular arrangement. The size of this structure is of the order of ¼ mm., and it is seen superposed on the ordinary dark cross due to strain, which extends across the whole disc. A rectangular plate of the same class of material showed the dark parts elongated into bands set in a definite direction, and suggestive of a flow structure. A circular disc of optical quality silica showed a spiral structure. A further study of the phenomena will be made. A. W.

89. *Choice of Glass for the Steinheil Aplanatic Lens.* **T. Kondo.** (Phys. Math. Soc. Japan, Proc. 1. pp. 295–303, Oct., 1919.)—Deals with the glass to be used for this lens, which consists of an ordinary crown double convex lens enclosed between two equal meniscus lenses of ordinary flint glass. The inner surfaces of the flint glass have about half the radii of curvature of the outer surfaces and the conditions to be fulfilled by the glass for freedom from chromatic and spherical aberrations and coma for unit magnification are considered. J. W. T. W.

90. *Secondary Spectrum of an Objective.* **E. Hertzsprung.** (Astron. Nachr. No. 207. p. 87, 1918. Zeits. Instrumentenk. 39. p. 289, Sept., 1919. Abstract.)—Describes a simple method for the determination of the secondary spectrum of a telescope objective. J. W. T. W.

91. *Three-lens Objective.* **K. Yamada.** (Phys. Math. Soc. Japan, Proc. 1. pp. 238–244, Sept., 1919.)—Describes a scheme of calculation for the three-lens objective. The paper is mathematical and cannot be usefully abstracted. J. W. T. W.

92. *Achromatic Quarter-wave Plate.* **E. Perucca.** (Accad. Sci. Torino, Atti, 54. 15. pp. 473–494, 1918–19.)—Describes the different forms of quarter-wave plates and their degrees of approximation to achromatism. A scheme is given for the examination of any crystalline plate for the determination of its quality as regards achromatism when employed for the purpose of a quarter-wave plate. J. W. T. W.

93. *Huyghens' Principle in Geometrical Optics.* **C. Somigliana.** (Accad. Sci. Torino, Atti, 54. 15. pp. 434–439, 1918–19.)—Shows that an advancing light-wave cannot be represented by a series of parallel surfaces unless these surfaces are planes, circular cylinders or spheres. J. W. T. W.

94. *Effect of Alteration of Radius on Achromatism of a Lens System.* **H. Erfle.** (Zeits. Instrumentenk. 39. pp. 233–241, Aug., 1919.)—For a given system of lenses, it is always considered that lengthening the focal distance by means of an alteration of the radius of one of the bounding lens surfaces causes an increase in the chromatic over-correction (or a decrease in the under-correction). It is shown that this is not invariably the case. J. W. T. W.

95. *Where Classical Optics Fails?* **E. Buchwald.** (Deutsch. Phys. Gesell., Verh. 21. pp. 492–494, July 30, 1919.)—A continuation of the work of M. v. Laue and that of de Haas, in which a photographic experiment showing the point at issue is described. An illustration of the result obtained is given and it is concluded that this completes the work of de Haas by a direct proof that the fluctuation appearance in the lycopodium (diffraction) image, at least in the first and second rings, shows, with sufficiently homogeneous light, not a ray-formed but a granular structure. A. E. G.

96. *Some Experiments and Remarks on Colour Theory.* **F. Exner.** (Akad. Wiss. Wien, Ber. 127. 2a. pp. 1829–1864, 1918.)—Rejecting the assumption of intensity as an independent quality of a colour sensation in the ordinary sense, E. Hering has, since 1874, advocated a purely phenomenological conception of colour sensation, which subsequently was supported chiefly by A. Hillebrand, in opposition to the Young-Helmholtz theory. According to Hering, brightness is a property inherent to three of the fundamental qualities of the sense of sight: white, yellow, red; and darkness similarly inherent to the three fundamental qualities, black, blue, green. The author shows that, on this theory of counter-colours, calculation would be impossible, if Hering and Hillebrand did not tacitly make several assumptions in their explanation of the brightnesses of colour mixtures: that there are three pairs of original sensations, red-green, yellow-blue, white-black; that the excitation of white is simultaneous with that of any coloured light; further, that this white-valency of a colour acts like brightness on the eye adapted to darkness; that each colour has a specific brightness by virtue of which it acts either by brightening (red-yellow) or by darkening (green-blue); and that this last effect is, like the others, additive. Experimentally some of Hering's assumptions have been disproved by A. König, by Kries and by Hauer, and the author describes novel experiments of his own made with rotating colour discs and with a König spectrophotometer, confirming the additivity of Young-Helmholtz for heterochromous brightnesses as against the specific brightness of Hering. H. B.

97. *Colorimetric Experiments.* IV. **O. Meissner.** (Phys. Zeits. 20. pp. 443–446, Oct. 1, 1919.)—An account of experiments made with 7 colour filters prepared by Ostwald; in most cases 2 or even 3 filters could be used so that a control could be effected. The continued experiments on the bleaching effect of daylight [Abs. 1030 and 1392 (1919)] show that the purity of some coloured filter-paper decreased by 50 % in a month and to about 1 % in six months. Further measurements have been made on the colours of tree-leaves in spring and autumn tints. H. B.

98. *Photoelectric Spectrophotometry by the Null Method.* **K. S. Gibson.** (Bureau of Standards, Bull. 15. pp. 325–352, [Sci. Papers No. 349], 1919.)—This paper describes in detail the apparatus and method of operation for reliable determinations of spectral transmission throughout the green, blue and violet by a photographic null method. The arrangement of apparatus is essentially the same as that used by Richtmyer [Abs. 1639 (1915)], but adapted to the needs of spectrophotometry. The apparatus has been in continual use since April, 1918, and has proved very satisfactory. All errors have been eliminated, as well as the necessity of any tests, calibrations or corrections, in connection with the current-irradiation law or the dark currents of the photoelectric cells, or with electrometer deflection methods. The only variable in the process of making a determination of the transmission at any wave-length is the accurately measurable distance of a small light-source from the slit of the spectrophotometer. Because of the higher sensitivity of the electrometer, it has been possible to make measurements over a greater range, and, at least for low values of transmission, with greater accuracy than could be obtained with a galvanometer. The accuracy was tested by measuring the transmission of rotating sectors of known aperture, and the transmission of standard glasses which had been measured by other methods, visual and photographic. The method is also applicable to the measurement of the relative radiant power of two sources and to the measurement of fluorescence, and could be extended into the ultra-violet if quartz parts were used instead of glass. A. W.

99. *Width of Spectrum Lines.* **G. Gianfranceschi.** (N. Cimento, 18. pp. 57–72, Aug., 1919.)—The author shows that the irreducible width of spectrum lines may be attributed to differences in the size of the emitting particles. The other possible factors, such as damping, absorption, Doppler-effect, are not essential to the finite character of the width. The author shows his hypothesis is capable of leading to Michelson's formula for the width of spectrum lines. E. E. F.

100. *Ionisation and Luminosity by Electron Collisions.* **F. Horton, [Miss] A. C. Davies** and **[Miss] D. Bailey.** (Engineering, 108. p. 468, Oct. 10, 1919. Paper read before the British Assoc.)—The problems investigated concern the disagreement between Bohr's hypothesis of the structure of the atom and the direct and indirect determinations of the critical velocities or voltages. Experiments are described with argon and helium, an apparatus of the Lenard type being used. The results showed that there were two critical velocities for the electrons, radiation appearing first at the lower critical velocity, and ionisation later at the higher. In argon the critical velocities corresponded respectively to p.d.'s of 11·5 and 15·1 volts, in helium to 20·4 and 25·6 volts. This latter value, 25·6 volts, is lower than Bohr's figure, 29 volts; on the other hand, the frequency limits calculated by the authors with the aid of the quantum relation agreed with the recent spectroscopic determinations of Lyman. The question as to whether the different series lines of helium required different minimal electron velocities for their excitation was particularly investigated. Once excited, the luminosity could be maintained by a slightly lower electron velocity. The series lines of helium were never found to be excited by less than 25 volts, and could not be maintained by less than 23 volts, and then only in the presence of some impurity. Moreover, none of the lines of helium would appear singly before the others. [See Abs. 781 (1919).] A. W.

101. *Electric Fields in the Surface of Chemical Atoms.* **J. Stark.** (Ann. d. Physik, 60. 1. pp. 196–200, Oct. 7, 1919).—The existence of electric fields at the surface of chemical atoms is shown both by the broadening and displacement of series lines due to increased gas pressure and current density, and by the appearance of certain series under the influence of electric fields. The present paper deals more particularly with the latter effect, fresh evidence being brought forward from the semi-sharp subordinate series and the nearly-diffuse subordinate series of lithium and helium. [See also Abs. 1071 (1914), 436 (1915), 1252, 1253, 1254 (1918) and 753 (1919).] A. W.

102. *Constitution of the Atom and Band Spectra.* **H. Deslandres.** (Comptes Rendus, 169. pp. 593–599, Oct. 6, 1919.)—A continuation of previous work [Abs. 1044 and 1203 (1919)]. The general formula for band spectra previously given, which includes three terms of the first degree in m, n and p, and three of the second degree in m^2, n^2 and p^2, appears to represent the algebraic sum of three longitudinal and three transverse vibrations, which are compounded like the components of a resultant sound. The formula thus corresponds to the most general motion of a solid body in three-dimensional space, and it should be noted that the formula is not a theoretical one, but has been arrived at by observation and experiment. Following up this idea, another formula is deduced, and the application of this latter formula to various spectra gives promising results. The results obtained show that the two formulæ lead to an intimate and simple connection between all band spectra, whether of emission or absorption. They agree well with observation, and suggest as an explanation the existence, in the atom or molecule, of both longitudinal and transverse vibrations, analogous to those of solid bodies. The longitudinal vibration should be predominant in absorption, and the transversal in emission, the difference being due to the difference of excitation in the two cases. In general, the two vibrations are both found in the case of emission spectra, as is the case in the emission of sound. The atom suggested by J. J. Thomson appears to suit best the ideas here brought forward. A. W.

103. *Wave-Length Measurements in the Spectra of Krypton and Xenon.* **P. W. Merrill.** (Bureau of Standards, Bull. 15. pp. 251–257 [Sci. Papers No. 345], 1919.)—This paper records photographic measurements of wave-lengths in the spectra of krypton and xenon, principally in the red and infra-red. In krypton 37 new lines were measured between λ6576 and λ8928; in xenon 52 new lines between λ6318 and λ9162. In this region there are numerous strong lines which are probably among the most important in the spectra of these elements. The xenon lines λ8231 and λ8280 are especially notable. These and other lines may be of value as wave-length standards in the infra-red. Attention is called to a probable analogy between the spectra of the rare gases neon, argon, krypton, and xenon. Observations upon neon and argon had previously shown that each spectrum possessed a group of very strong lines in the red, with the further characteristic that the shortest lines of the group were especially strong, and that in the direction of the violet from these lines lay a region containing only weak lines. The krypton spectrum exhibits somewhat the same phenomena, and this is probably also the case with xenon, the very strong lines λ8231 and λ8280 beginning a group of strong lines, which, however, is not very conspicuous or greatly extended owing to the rapidly decreasing efficiency of the photographic plate in this portion of the spectrum. Moreover, strong lines or groups of the four gases show a regular displacement from one spectrum to another in the order of the atomic weights. Photographs with a small-dispersion spectrograph show this plainly, the progression in the position of two groups of lines being very striking. The correspondence between individual lines is not clear, and no extended search for individual relationships has as yet been made. A. W.

104. *Arc Spectrum of Dysprosium.* **J. M. Eder.** (Akad. Wiss. Wien, Ber. 127. 2a. pp. 1099–1228, 1918.)—Continuing the systematic investigation of the spectra of the rare earths [see Abs. 895 (1919)] the author has studied the arc spectrum of dysprosium preparations obtained by fractionation methods by v. Welsbach. A table is given of the wave-lengths of about 4400 lines from $\lambda 7000$ to $\lambda 2286$. The measurements of Exner and Haschek and of Eberhard are included for comparison. A. W.

105. *Spectra of Isotopes.* **T. R. Merton.** (Nature, 104. p. 93, Oct. 2, 1919.)—The author refers to a careful determination of the difference of wave-lengths of the principal line in the spectra of ordinary lead and of lead from Australian carnotite. He obtains a value in good agreement with that obtained by Aronberg [Abs. 678 (1918)] amounting to 0·0043 Å. The author has also found a difference between the wave-lengths of the principal line in ordinary lead and lead from Ceylon thorite, and promises to publish shortly some results which indicate that the thallium in pitchblende is an isotope of ordinary thallium and more probably of greater atomic weight. It is suggested that spectroscopic methods furnish a simple and comparatively rapid method of distinguishing isotopes. A. B. W.

106. *A New Effect of the Rays in Light-sensitive Layers.* **F. Weigert.** (Deutsch. Phys. Gesell., Verh. 21. pp. 479–491, July 30, 1919.)—The simplest and quickest method by which the phenomenon here dealt with can be demonstrated is to allow some ordinary photographic paper to become moderately blackened by exposure to diffuse daylight, and then to project on this the image of the crater of an arc lamp after the rays have passed through a water filter, a red glass disc and a Nicol prism. After a lighting of about 5 minutes, a very distinct red spot is formed on the paper. If this be viewed through a Nicol prism which is slowly turned before the eye, a decrease and increase of the intensity is clearly visible. There are well-marked maximum and minimum positions, but there is no complete blotting-out as is the case with crossed nicols. From this and other described observations it is concluded that isotropic layers can be rendered double-refracting by irradiation. Light-sensitive layers by irradiation with linear polarised light become dichroitic, a proof that not only in crystals but also in amorphous substances in which the molecules are completely irregularly oriented, the absorption-electrons only lay claim to a certain oscillation plane of electric vectors always according to the place of the isolated molecule. A. E. G.

107. *Fluorescence and Absorption of the Uranyl Acetates.* **E. L. Nichols, H. L. Howes** and **[Miss] F. G. Wick.** (Phys. Rev. 14. pp. 201–221, Sept., 1919.)—The spectra of the uranyl chlorides and nitrates have been dealt with in previous papers [Abs. 75 and 1349 (1916), 67 and 779 (1918)]. The present paper is concerned with the fluorescence and absorption spectra of the two known forms of uranyl acetate and of thirteen double uranyl acetates as they appear when excited at the temperature of liquid air. The spectra of the uranyl acetates consist of the usual equidistant fluorescence bands. When excitation occurs at the temperature of liquid air, these bands are resolved into groups, the homologous members of which form series of constant frequency interval. There are two single acetates, a finely powdered, anhydrous variety and a crystalline form with two molecules of water of crystallisation, whose spectra differ widely, particularly as to the groups of fluorescence bands. Of the double acetates, those containing Li, K, Ca, Mn and Sr have spectra which may be regarded as essentially identical both as regards the location of the principal bands and the structure of the fluorescence groups. The only distinctions between their spectra are in the sharpness of resolution and relative brightness of the various components. The spectrum of barium uranyl acetate differs from the above in that the groups are shifted, as a whole, about five frequency units towards the red. In the spectra of the double acetates of ammonium and rubidium, band D in each group is doubled, but there is no shift of the groups. The presence of Na, Mg, Zn, Ag, and Pb modifies the group structure by the addition of bands characteristic of the metal, and causes slight relative displacements of the group system as a whole. Otherwise the spectra resemble those of the double acetates containing Li, K, etc. The frequency interval for the fluorescence series of the double acetates is probably the same for all series and for all salts, the departures of the general averages for the various salts being less than one frequency unit from the average for all; *i.e.* 84·76. The same is probably true of the absorption series, the general average for which is 70·68. The frequency intervals, both in the fluorescence and absorption spectra, are larger by more than one frequency unit for the single acetates than for the double acetates. A. W.

108. *Critical Absorption and Characteristic Emission X-Ray Frequencies.* **W. Duane** and **Kang-Fuh-Hu.** (Phys. Rev. 14. pp. 369–375, Oct., 1919.)—Accurate measurements were made with the X-ray spectrometer [see Abs. 291 (1918)] of the critical absorption, the critical ionisation and the highest characteristic emission frequencies associated with one single X-ray series; the series chosen being the K-series of rhodium. The wave-lengths of the lines in the K-series spectrum of rhodium were found to be as follows:—

$K\alpha_2$	$0·6164 \times 10^{-8}$ cm.	$K\beta$...........	$0·5453 \times 10^{-8}$ cm.
$K\alpha_1$	$0·6121 \times 10^{-8}$ cm.	$K\gamma$..........	$0·5342 \times 10^{-8}$ cm.

From the observations made, the authors conclude that the critical ionisation frequency is equal to the critical absorption frequency to within considerably less than 1/10 %, and that the critical absorption frequency exceeds the frequency of the γ-line in the emission series by 1/4 % or 1/3 %, these being determined by measuring from the centres of the drops and peaks in the curves corresponding to them respectively. E. A. O.

109. *Precision Measurements of X-Ray Spectra.* II. **M. Siegbahn.** (Phil. Mag. 38. pp. 639–646, Nov., 1919.)—In a previous paper [Abs. 1397 (1919)] the author described a vacuum spectrograph suitable for the measurement of X-ray wave-lengths greater than 1 Å.U. The present paper contains a description of another spectrograph especially designed for the investigation of short waves having wave-lengths up to 0·5 Å.U.

The wave-lengths of the lines in the K-series spectrum of tungsten, measured with the instrument, are entered in the last column of the following table, which contains in addition the results of other investigators on the K-series spectrum of the same element as summarised by the author. The figures in the table are in terms of 10^{-11} cm. as unit of wave-length.

	de Broglie.	Hull and Rice.	Ledoux-Lebard and A. Dauvillier.	E. Dershem.	Siegbahn.
$K\alpha_2$	203	218	212·8	212·4	213·52
$K\alpha_1$		214	205·3	207·6	208·85
$K\beta_1$	177	192	182·6	183·4	184·36
$K\beta_2$	—	—	176·8	178·4	179·40

The latter part of the paper gives the results of measurements of the L-series spectrum of tungsten taken with the vacuum spectrograph. Both calcite and rock-salt were used as reflectors. Good agreement was obtained between the two sets of observations, which confirmed the accuracy of the relative values of the lattice constants of these two crystals previously published in Part I. The L-series spectrum consists of three groups of lines, α, β and γ. In the present work, at least 13 lines—and possibly 18 lines—were found in the whole L-series spectrum of tungsten. III. **M. Siegbahn** and **A. B. Leide.** (*Ibid.* 38. pp. 647–651, Nov., 1919.)—This paper contains a description of an X-ray spectrograph for the investigation of medium wave-lengths, ranging from 0·5° to about 2·0 Å.U. It was built to bridge the gap between the two spectrographs alluded to. The wave-lengths of the lines in the K-series spectrum of Cu were the shortest measured with the vacuum spectrograph, λ for $Cu-K\alpha_1$ being $1537{\cdot}36 \times 10^{-11}$ cm. With the new spectrograph λ for $Cu-K\alpha_1$ was found to be $1537{\cdot}44 \times 10^{-11}$ cm., the two values differing by about 0·005 %. It is pointed out, however, that at these wave-lengths the vacuum spectrograph gives the greater accuracy, as the angle to be measured is then the four-fold reflection angle. Very sharp lines may be obtained with this new instrument, down to wave-lengths as short as 0·2 Å.U., a gold slit being used. E. A. O.

110. *Soft X-Rays.* **H. M. Dadourian.** (Phys. Rev. 14. pp. 234–246, Sept., 1919.)—The following synopsis of this paper is given by the author.

Soft X-rays were produced by the impact of electrons from a hot-line kathode against a Pt anode. Potentials of 20 to 1000 volts were used to give the electrons the desired velocity of impact. The properties of the rays were studied by observing the velocity and number of electrons produced on a brass plate by a narrow beam of soft X-rays. Soft X-rays were obtained with potentials as low as 20 volts. Radio-electric curves were obtained under different experimental conditions, these curves having the general shape of photoelectric curves, but differing from them in several important particulars. The velocity distribution of radio-electrons was studied, when it was found that only a negligible fraction of the electrons have velocities comparable with the velocity of impact of the kathode electrons. Evidence was obtained of the presence of

L-radiations of copper and zinc of approximate wave-lengths of 15×10^{-8} and 13×10^{-8} cm. respectively, and of softer characteristic rays of platinum of approximate wave-lengths of 21×10^{-8} and 31×10^{-8} cm. It is pointed out that the method used in this investigation, which is called the radio-electric method, lends itself to the study of characteristic radiations of elements of low atomic numbers. A. B. W.

RADIO-ACTIVITY.

111. *Recoil of α-Particles from Light Atoms.* **L. B. Loeb.** (Phil. Mag. 38. pp. 533-541, Nov., 1919.)—Rutherford [Abs. 912 (1919)] has recently shown that when swift α-particles collide with light atoms (*e.g.* atoms of H, N, O) the number of these atoms projected straight forward within an angle of 10° with the original direction of the α-particles is from 10 to 30 times as great as that demanded by the theory of point-charges worked out by C. G. Darwin [Abs. 1032 (1914)]. From these results Rutherford concludes that in collisions between an α-particle and a nitrogen atom where the distance of approach of the centres of the atoms is less than $7{\cdot}0 \times 10^{-13}$ cm., the magnitude and directions of the forces involved are entirely different from those acting at greater distances. He assumes that in collisions where the distance of approach is less than the value above, we are dealing with the actual impacts of the nuclei themselves. A study of such encounters should obviously throw important light on the nuclear structure and dimensions.

The author now describes experiments in which he attempts to verify the above results by a study of the number of α-particles *recoiling* after such close encounters. A study, not yet completed, was made of the deflections of α-particles through large angles by light atoms. So far as they go, the results indicate that collisions where the centres of the atoms of He and Al approach within 7×10^{-13} cm. of each other begin to show the abnormalities found by Rutherford for nitrogen and hydrogen. The range of the α-particles after deflection from Al at 105° lies below 3·6 cm., as would be expected if the laws of momentum and energy hold. It is the author's impression that in spite of the experimental difficulties—low "counts," short range, γ-ray effects and stray particles—a definite decision as to the abnormality of aluminium ought to be possible at an angle of 170°. A. B. W.

112. *Electrons Liberated by Slow Positive Rays.* **H. Baerwald.** (Ann. d. Physik, 60. 1. pp. 1–29, Sept. 26, 1919.)—In a former paper [Abs. 1470 (1913)] the author has described an investigation of the production of electrons by the impact of high-velocity canal rays on solid substances. The results obtained were in general agreement with those of Campbell in the case of the production of δ-rays by the impact of α-particles on solid matter. The following laws were established: (*a*) The amount of secondary radiation is proportional to the intensity of the primary beam. (*b*) The velocity of the secondary radiation is independent of the intensity of the primary beam, and only depends on the velocity. (*c*) The existence of secondary radiation can be detected with primary velocities corresponding to a voltage as low as 900. In this case the secondary particles have a velocity corresponding to 4–6 volts. (*d*) The amount of secondary radiation was found to be independent of the nature

of the substance radiated by the canal rays, being dependent only on the current density of the primary rays.

After referring to the work of other investigators on this subject, the author outlines the object of the present investigation and the experimental method employed. A determination is first made of the limiting velocity of the primary positive rays for the production of secondary electron-emission. The results indicate that this limiting voltage lies between 20–30 volts (although the curve connecting secondary current and primary voltage approaches the voltage axis asymptotically, showing no indication of a "limiting" voltage). An examination was also made of the distribution of the secondary electrons liberated and its variation with the primary velocity of the positive rays. A. B. W.

113. *The Counting of α-particles.* **R. W. Lawson** and **V. F. Hess.** (Akad. Wiss. Wien, Ber. 127. 2a. pp. 599–629, 1918.)—In a former communication the authors have described methods of counting α-particles based on the "Collision Method," due to Rutherford and Geiger. In these methods the interfering effects of β- and γ-rays have been partially eliminated. An examination was made of the following gases to find one suitable for the counting experiments: (*a*) nitrogen, (*b*) oxygen, (*c*) hydrogen, (*d*) CO_2, and (*e*) mixtures of CO_2 and air. The three first-named gases are similar to air, in that β- and γ-rays produce in them ionisation by collision. The same may be said of mixtures of CO_2 and air, if 50 % or more of air is present. The most suitable mixture for counting purposes has been found to contain 54 % CO_2 and 46 % air. With this mixture the collision effect due to β- and γ-rays is reduced to a minimum; a correction being easily and accurately determined.

The experiments have been extended to the counting of H-rays produced by the close impact of α-particles with hydrogen atoms. The results of such determinations are consistent with Darwin's theory [Abs. 1032 (1914)] and with Rutherford's observations [Abs. 1347 (1911) and 1031 (1914)].

In a further investigation a determination has been made of the number of abnormally long-range α-particles emitted from RaC, analogous to those found by Rutherford and Wood [Abs. 689 (1916)] in the case of ThC. The experiments have led to the conclusion that in the case of RaC such long-range α-particles probably do not exist. Or if they do exist, their number is less than 1/50,000 of the number of ordinary α-particles from RaC.

In conclusion, the authors give an accurate table of decay of RaC for long exposure in RaEm. The authors have employed this table in all their investigations in which RaC has been employed. A. B. W.

HEAT.

114. *Thermal Conductivity of Heat Insulators.* **W. M. Thornton.** (Engineering, 108. pp. 369–370, Sept. 19, 1919. Paper read before the British Assoc., Bournemouth, 1919.)—For true insulators the coefficient of thermal conductivity is found to be $k = V^2\varrho^2$ and, since $V^2 = E/\varrho$, k also $= E\varrho$, where V is the velocity of sound, ϱ the density and E the elasticity. For flint glass, *e.g.*, $E\varrho = 14{\cdot}1$, $V^2\varrho^2 = 14{\cdot}1$, $k = 14{\cdot}3$; for graphite the figures are 12·1, 11·5, 12·0; for paraffin wax 0·14, 0·14, 0·141; but the relation does not hold for india-rubber and cork, which have peculiar elastic properties. From the kinetic theory it further follows that the ratio of the velocity of sound to the velocity of the atomic thermal vibrations in insulators is $2{\cdot}9 \times 10^{10}$, and the relations can be deduced by simple electromagnetic considerations. A good heat insulator should be light and inelastic; the latter is a new point. In the *discussion*, **A. Lupton** remarked that, if he understood rightly, the rocks of coal measures, which were inelastic, but dense, should not be good insulators; the author replied that these rocks fitted his rule. H. B.

115. *Thermal Constants of Technical Metals.* **F. Wüst, A. Meuthen and R. Durrer.** (V.D.I. Forschungsarbeiten, No. 204, 1918. Zeits. Instrumentenk. 39. pp. 294–295, Sept., 1919. Abstract.)—A Bunsen ice-calorimeter was combined after Oberhoffer with an electric vacuum furnace (carbon spiral) to heat metal specimens of several gm. weight up to 1600° within quartz tubes. The experiments yield directly the total heat between the furnace temperature and 0°, and the curves show the points of transformation; the heat of a transformation is found from the differences of the total heats before and after the transformation. Heats of fusion were also determined, and formulæ deduced for the mean and the true specific heat. The transformations observed are: Manganese, 1070 to 1130°, 24 cals./gm.; nickel, 320 to 330°, 1·3 cals.; cobalt, 950 to 1100°, 14·7 cals.; iron, three transformations, 725 to 785°, 6·6 cals., 919°, 6·7 cals., and 1404·5, 1·9 cals. The following are some of the values of melting-point and heat of fusion: Sn 232°, 13·79 cals./gm.; Bi 270°, 10·23; Pb 327°, 5·47; Zn 419°, 23·01; Sb 630°, 38·86; Al 657°, 93·96; Ag 961°, 26·02; Au 1064°, 15·87; Cu 1084, 40·97; Mn 1210°, 36·65; Ni 1451, 56·08; Co 1478°, 58·23; Fe 1528°, 49·35. All the metals studied (except Ni, Mn, Cd) have a smaller mean specific heat in the liquid than in the solid state. The differences are mostly small, of the order of a few per cent.; no differences were observed in the cases of Pb and Bi. The atomic heats found range between 6 and 12. The true specific heats are expressed by the formula $s = a + bt$ and the constants a and $b \times 10^6$ are tabulated separately for various temperature ranges; *e.g.* Al, range 0 + 657°, and 657 to 1000°, $a = 0{\cdot}22200$ and $0{\cdot}21870$, $b = 77{\cdot}14$ and $48{\cdot}00$; in the case of iron five ranges are distinguished; copper, 0 to 1084° and 1084 to 1300°, $a = 0{\cdot}10079$ and $-0{\cdot}04150$, $b = 6{\cdot}10$ and $131{\cdot}20$. H. B.

116. *Brightness of a Black Body at the Gold and Palladium Melting Points.* **F. Hoffmann and W. Meissner.** (Ann. d. Physik, 60. 3. pp. 201–232, Oct. 20, 1919. From the Physikal.-Techn. Reichsanstalt.)

—The brightness of a black body was determined by means of a König-Martens photometer, the black body being maintained at the melting-point of Au or Pd in the first case by immersion in a bath of measured temperature; in the second case by immersion in the melting metal. The ratio of the brightnesses at the Au and Pd melting-points was found to be 81·5 at a wave-length of 0·6563μ. If c be taken as 14,300 and the gold point as 1063°, the palladium point becomes 1557°, a value approximately 8 deg. higher than Day and Sosman's value obtained by direct gas thermometry. J. W. T. W.

117. *Residual and Extinctive Atmospheres of Flames.* **T. F. E. Rhead.** (Soc. Chem. Ind., J. 37. pp. 274–278 T, Aug. 31, 1918.)—This research, interrupted by the war, and not resumed, was conducted at the Home Office Explosion in Mines Station to determine both (1) the residual atmosphere remaining after the flame of some combustible gas has been extinguished, and (2) the extinctive atmosphere, *i.e.* the mixture of oxygen and some other gas which will just sustain combustion. The two atmospheres are not the same. In determining (1) the chief difficulty is that the hot products of the combustion remain in the vessel and heat it, thus both shortening and lengthening the time. Experiments were made in vessels of 1·5 litres and 12 litres' capacity. The oxygen contents of (1) are: for flames of methane, propane, butane, pentane, from 15·6 to 16·4 %, increasing with the molecular weight; for cyanogen 15·3, carbon monoxide 10·2, hydrogen 5·7 %. In both (1) and (2) the oxygen percentage left depends upon the rate of diffusion of the combustible gas in the atmosphere and upon the nature of the combustion process; in the case of hydrogen the rate is high, and the reaction simple. To study (2) the flame is fed with a definite oxygen mixture at definite rates. The hydrocarbons mentioned all gave practically the same oxygen percentage, 16·3 to 16·6; the rate of feed in so far alters the results, as less oxygen will sustain combustion for a longer period when the rate is raised. Coal gas, being essentially a mixture of two combustible gases, hydrogen and methane, of which the former burns preferentially, differs from a pure gas and has two extinctive atmospheres; the methane acts in a sense as a diluent, and hence the oxygen content in (2) is diminished when the rate of feed is increased. H. B.

118. *On the Kinetic Theory of the Internal Friction of Gases.* **G. Jäger.** (Akad. Wiss. Wien, Ber. 127. 2a. pp. 849–870, 1918.)—The author first deals with the Jeans correction of the ordinary expression for the average free path of a gas molecule, whereby not the true free path, but the condition before the previous impact, has to be taken into account. When $\vartheta = 0{\cdot}406$, the free path is $l_r = l\,(1 + \tfrac{1}{2}\vartheta + \tfrac{1}{3}\vartheta^2 + \ldots) = 1{\cdot}319 l$, and for diffusion $l_a = l\,(1 + \vartheta + \vartheta^2 + \ldots) = 1{\cdot}771\, l$. Valentiner's work is noted [see Abs. 392 (1914)]. The author states that his work on the subject was prior to that of Jeans and he now gives a *résumé* of this in the present paper. In the author's opinion, however, the investigation by Jeans was not sufficiently rigid, so the present paper has been written to show how an exact result may be obtained without any further simplifying assumptions. H. H. Ho.

119. *Density of the Saturated Vapour of Propyl Acetate and of the Liquid which emits this Vapour.* **E. Ariès.** (Comptes Rendus, 169. pp. 216–219,

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Aug. 4, 1919.)—The densities of a saturated vapour and of its liquid, or in other words the molecular volumes v_1 and v_2 of the fluid in its two states of saturation, are given for each temperature by the following formulæ [see Abs. 762 (1919)]:

$$v_1 = \mathrm{RT}_c\tau(a + y_1)/8\mathrm{P}_c\tau^{n+1} = \mathrm{RT}_c\Gamma(a + y_1)/8\mathrm{P}_c,$$

and similarly for v_2 with y_2 instead of y_1. The function a, which is necessary for the application and verification of these formulæ is as yet unknown. In the present paper, this function is determined for propyl acetate by a method similar to that previously used [see Abs. 1415 (1919)] for the determination of function Γ for the same body. Either of the above formulæ may be used for this purpose, but the function a always maintains a very small value, less than unity, for v_2, so that it is preferable to utilise v_1. The following expression has been adopted as most suitable: $a = a_c + (1 - \tau)/\mathrm{A} + \mathrm{B}\tau + \mathrm{C}\tau^2$, a_c being the value which the function takes at the critical point ($\tau = 1$). Using Young's data for propyl acetate, $a_c = 0{\cdot}056847$, and by calculation from the data at 110°, 180° and 250°, $\mathrm{A} = 3{\cdot}6511$, $\mathrm{B} = -5{\cdot}4612$, and $\mathrm{C} = 1{\cdot}8881$. By means of the above formulæ the molecular volumes v_1 and v_2 may be found for propyl acetate, at any temperature. A comparison table is given of the calculated and observed values for a temperature range of 90° – 276·2 (crit.), by which very satisfactory concord is shown, especially for the liquid state, and, except at 240° and 270°, for the saturated vapour. H. H. Ho.

120. *Formula for Saturated Vapours.* **A. Köhler.** (Zeits. Vereines Deutsch. Ing. 63. p. 1097, Nov. 1, 1919.)—Gives the following empirical formula for saturated vapours and shows that it represents satisfactorily the experimental results: $(p_s/p)^a = (\mathrm{T}_s/\mathrm{T})$, c_p/c_v where $1/a = 10 + \log(p_s/p)$, p_s is the pressure in mm. of mercury, T_s the absolute temperature at boiling-point, p the pressure at temperature T. J. W. T. W.

121. *Maximum Vapour Pressures of Benzene and* Cyclo*hexane at Moderate Temperatures and Calculation of their Principal Specific Heats.* **G. Déjardin.** (Ann. de Physique, 12. pp. 253–291, May-June, 1919.)—An improved Regnault apparatus was used for measuring the vapour pressures of benzene and *cyclo*hexane, the latter substance being a synthetic product prepared by the method of Sabatier and Senderens. The vapour pressure ($\mp$) of benzene is represented by the formula: $\log \mp = 0{\cdot}87476 + 0{\cdot}020670(t - 20) - 755 \times 10^{-7}(t-20)^2 + 16{\cdot}5 \times 10^{-8}(t-20)^3$; that of *cyclo*hexane by: $\log \mp = 0{\cdot}88264 + 0{\cdot}020688(t - 20) - 844 \times 10^{-7}(t - 20)^2 + 23 \times 10^{-8}(t - 20)^3$; the range of temperatures is 80·00°–80·35° for benzene and 80·66°–81·06° for *cyclo*hexane. The b. pts. of the two compounds at 76 cm. are 80·15° and 80·85° respectively. The values of $\mp$ calculated by means of these formulæ for temperatures varying between 17° and 100° are found to be in good agreement with the experimental values obtained by other observers. The critical pressure of benzene, calculated by Leduc's formula [compare Abs. 1384 (1912), 1008 (1913)], is found to be 56 atmos., as compared with Young's experimental value of 47·89 atmos. Young and Fortey give the critical pressure of *cyclo*hexane as 39·8 atmos., but the use of this value shows that the vapour does not obey the law of corresponding conditions; the author adopts the value of 50 atmos., which gives a good agreement between theory and experiment. The latent heat of vaporisation (L) of benzene, between

20° and 140° is given by the formula: $L = 106{\cdot}55 - 0{\cdot}130t - 29 \times 10^{-5}t^2$; that of *cyclo*hexane between 20° and 90° by: $L = 99{\cdot}28 - 0{\cdot}166t - 11 \times 10^{-5}t^2$. The specific heats of benzene and *cyclo*hexane were determined by measuring the rise in temperature of a known weight of the liquid, contained in a Dewar vessel, when a known quantity of heat was supplied by the passage of an electric current through a managanin wire spiral immersed in the liquid. Heat insulation was improved by surrounding the Dewar vessel containing the liquid with another Dewar vessel. Between 23° and 52° the specific heat (x) of benzene is given by the formula: $x = 0{\cdot}399 + 85 \times 10^{-5}t$; that of *cyclo*hexane by: $x = 0{\cdot}491 + 35 \times 10^{-5}t$. Using Leduc's formula (*loc. cit.*) the ratio (γ) of the specific heats for benzene is then found to be given by the formula: $\gamma = 1{\cdot}1066 - 22 \times 10^{-5}t + 21{\cdot}10 \times 10^{-7}t^2$, γ having a minimum value of 1·101 at 50°. For benzene, Mills and MacRae (J. Phys. Chem. 14, 797, 1910) have found $x = 0{\cdot}397 + 57 \times 10^{-5}t$, which gives $\gamma = 1{\cdot}1083 - 15 \times 10^{-5}t + 23 \times 10^{-7}t^2$, showing a minimum value for γ of 1·106 at 30°. In his further calculations the author adopts the equation $\gamma = 1{\cdot}1075 - 18{\cdot}5 \times 10^{-5}t + 22 \times 10^{-7}t^2$, the mean of the above two equations, which gives a minimum value for γ of 1·1035 at 40°. The velocity of sound in saturated benzene vapour at 100° is then calculated by Leduc's formula to be 199·3 m./sec. The specific heat (C) at constant pressure for benzene is given by the formula: $C = 0{\cdot}271 + 37 \times 10^{-5}t + 23{\cdot}5 \times 10^{-7}t^2$. The value of γ for *cyclo*hexane between 20° and 90° is practically constant and equal to 1·077 and the velocity of sound in the saturated vapour at 80° is calculated to be 181·7 m./sec., that of benzene at the same temperature being 197·1 m./sec. The specific heat at constant pressure is given by the formula: $C = 0{\cdot}331 + 53 \times 10^{-5}t + 3 \times 10^{-6}t^2$.

Using the formula $\gamma = 1 + 2/(\mu + \mu')$, where μ is the number of degrees of liberty relative to the kinetic energy of the molecule, and μ' the number relative to the intramolecular potential energy, the author finds $\gamma = 1{\cdot}111$ for benzene, the number of degrees of liberty, from chemical considerations, being taken as 15. For *cyclo*hexane $\gamma = 1{\cdot}083$ or 1·074 according as the number of degrees of liberty is taken as 24 or 27. T. S. P.

122. *Calculation of the Ratio between the Vapour Pressure of a Solid and that of the Supercooled Liquid at different Temperatures.* **A. Boutaric.** (Comptes Rendus, 169. pp. 432–435, Sept. 1, 1919.)—The solidification at the absolute temperature T° of a gm. mol. of a supercooled liquid involves a diminution of free energy whose expression is $A = RT \log_e(p_1/p_2)$, where p_1 and p_2 are the respective vapour pressures of the supercooled liquid and solid at temperature T. According to Nernst's hypothesis the total energy diminution U and that of free energy A, during a transformation may be expressed by the relations:

$$U = U_0 + \beta T^2 + \gamma T^3 + \delta T^4 + \ldots$$
$$A = U_0 - \beta T^2 - \gamma/2T^3 - \delta/3T^4 - \ldots$$

where the coefficients $U_0, \beta, \gamma, \delta \ldots$ depend on the particular transformation. In practice, within not too extended temperature intervals, the expressions may be restricted to the first two terms; that is, $U = U_0 + \beta T^2$; $A = U_0 - \beta T^2$. If θ be the transformation temperature for which the variation A of free energy is zero, and U_θ the corresponding diminution in total energy at this temperature, then $A = U_\theta/2(1 - T^2/\theta^2)$, from which $\log_e p_1/p_2 = U_\theta/2RT(1 - T^2/\theta^2)$, a formula which only involves U_θ and θ, *i.e.* the heats and temperature of fusion, to an approximation sufficient for experimental verification. The vapour pressures p_1 and p_2 relating to the supercooled liquid and solid have only been measured for a small number of substances; *e.g.* water, benzene, and formic acid are the only ones cited in the *Recueil de Constantes physiques*. A table is given showing an excellent accord between the calculated and observed values for water, which is as good as that given by the more complex empirical formulæ of Scheel and Heuse, etc. For benzene the departures are of the order of experimental error. For formic acid the experimental values observed by Kahlbaum differ clearly from those calculated. An analogous divergence is found on calculating the heat of fusion by the difference between the heat of volatilisation of the supercooled liquid and the heat of sublimation of the solid deduced from the vapour-pressure curves; this difference is more than double the experimental value.

The conclusion is drawn that the measurements are erroneous and merit repetition. H. H. Ho.

123. *Most Probable Value of Planck's Constant.* **R. T. Birge.** (Phys. Rev. 14. pp. 361–368, Oct., 1919.)—There are now seven distinct methods leading to a value of Planck's constant, *h*. The latest available results by all these methods have been collected and the most probable value and probable error computed for each method. The results are as follows:

Method.	Value of *h*.	Residual.	Dependence on *e*.
Total radiation constant (ς)	6·551 ± 0·009	− 0·0033	$e^{4/3}$
Wien constant	6·557 ± 0·013	+ 0·0027	e
Theory of atomic structure	6·542 ± 0·011	− 0·0123	$e^{5/3}$
Einstein's photoelectric equation	6·578 ± 0·026	+ 0·0237	e
Lewis and Adams' theory of ultimate rational units......	6·555 ± 0·009	+ 0·0007	$e^{4/3}$
	6·560 ± 0·014	+ 0·0057	e^2
Quantum relation applied to ionisation potentials	6·579 ± 0·021	+ 0·0247	e

The mean value of *h* is $6{\cdot}5543 \pm 0{\cdot}0025 \times 10^{-27}$ erg. sec., assuming $e = 4{\cdot}774$, with a percentage error somewhat greater than that of *e*, and in the same sense. J. W. T. W.

124. *The Adiabatics of Carbon Dioxide at High Temperatures.* **K. Neumann.** (Zeits. Vereines Deutsch. Ing. 63. pp. 1002–1007, Oct. 11, 1919.)—This paper is a contribution towards obtaining information with respect to the efficiency of heat engines. The older method of the thermodynamic cycle is no longer complete, and has to be suitably modified. The chief reason for this is that the process in combustion engines does not take place in a closed cycle, but the specific heats of the gases are functions of pressure and temperature, while the combustion itself is not a reversible process, so that the working substance changes its chemical behaviour during the actual course of the operation Compression and expansion take place in the cylinder, the former at relatively low temperatures, the latter at very high ones. Since during combustion within the dissociation limits a molecular change occurs, so during adiabatic expansion a change in the composition of the gas components will take place corresponding to the displacement of the equilibrium of the chemical reaction. As a consequence of this dissociation only partial combustion occurs during the expansion, leaving a further combustion to take place afterwards. The latter constitutes a characteristic for the different machines.

In the present paper the simple case is investigated where only carbon dioxide constitutes the working substance, a reason for the choice being that its specific heat is known with certainty at very high temperatures. A cylinder, which is a thermal non-conductor, is filled with carbon dioxide and heated at constant volume to a high temperature. The dissociated gas mixture of CO_2, CO, and O_2 is expanded adiabatically and the courses of the adiabatics, as well as the changes in gas composition, are found. In a technical gas mixture the dissociation depends on the combustion temperature attained, which in turn is conditioned by the state and thermal content of the charge at the end of the compression.

Tables and diagrams accompany the paper. H. H. Ho.

SOUND.

125. *Vibration and Syneresis of Silicic Acid Gels.* **H. N. Holmes, W. E. Kaufmann** and **H. O. Nicholas.** (Am. Chem. Soc., J. 41. pp. 1329–1336, Sept., 1919.)—An experimental research, the chief results of which are as follows:—Vibrating silicic acid gels were made which, on tapping, produced a tone two octaves above middle C. Such gels vibrate as elastic solids, but tension is an important factor. That they are under considerable tension is proved by their great contraction in vaselined tubes. Contracted gels removed from vaselined tubes have a lower vibration frequency than similar gels adhering to the walls of tubes of equal diameters. Since vibration frequency varies inversely as the diameter of gel column, tension must exert some influence on pitch. Vibration frequency varies directly as the concentration of silicic acid, increases with excess of mineral acids, but decreases with excess of organic acids. Syneresis (separation of water solution from gels) increases with increase in concentration of silicic acid, increases with excess of mineral acids, and decreases with excess of organic acids. For acid gels the factors that increase vibration frequency increase syneresis also. Syneresis varies directly as the free surface. When gels contract in vaselined tubes far more liquid separates than from equal volumes of gel in plain tubes to which the gel adheres. The extreme in syneresis was observed with moderately basic gels. The solution synerised was as much as 90% of the volume of the gel in some cases. E. H. B.

126. *Vibrating Strings as Measurers of Elongation.* **O. Schaefer.** (Zeits. Vereines Deutsch. Ing. 63. pp. 1008–1009, Oct. 11, 1919.)—Describes an application of the change in pitch of a vibrating string with the distance apart of its ends to a measurement of the elongation of a member under tension, the string being attached to two projections or lugs on the member in question. E. H. B.

127. *Influence of Horizontal Temperature Layers of Sea Water on the Range of Submarine Signalling.* **H. Lichte.** (Phys. Zeits. 20. pp. 385–389, Sept. 1, 1919.)—Discusses the question of the propagation of sound under the sea with different conditions as to temperature of the various layers. The paper is illustrated by a number of diagrams and graphs. E. H. B.

128. *Bells.* **J. Biehle.** (Phys. Zeits. 20. pp. 429–431, Sept. 15, 1919. Review by F. Weisbach.)—This volume includes an analysis of the tones of bells, showing what deviations from the ideal tone occur in actual bells of various types. It then passes on to the subject of steel bells and compares them with those of bronze. E. H. B.

129. *Acoustics of Sudden Sounds.* **O. Abraham.** (Ann. d. Physik, 60. 8. pp. 55–76, Sept. 26, 1919.)—An elaborate and detailed investigation as to sounds of short duration made with a few holes only in a siren and the sudden sounds or noises by which they are found to be accom-

panied. The whole is found to be in agreement with the resonance theory of audition. E. H. B.

130. *Head Waves and Source of Sound Reports.* **A. Timpe.** (Phys. Zeits. 20. pp. 396–398, Sept. 1, 1919.)—Discusses the phenomena of double reports sometimes heard in warfare. E. H. B.

131. *Sensitive Flame.* **H. Mache.** (Phys. Zeits. 20. pp. 467–468, Oct. 15, 1919.)—Describes a sensitive flame made by fitting a funnel to one of the air-holes of a Bunsen burner, the vertex of the funnel nearly coinciding with the point at which the gas jet issues. The other air hole is closed. A thin diaphragm may be placed in the funnel, not at the mouth but fairly near the small end. E. H. B.

132. *Hydrodynamics of Aeolian Tones.* **F. Krüger.** (Ann. d. Physik, 60. 3. pp. 279–290, Oct. 20, 1919.)—In a previous paper [Abs. 1567 (1914)] the dependence of the so-called aeolian tones on the vortex motion occurring was discussed. Out of the theory there developed emerges the relation ND/U = constant, where N is the frequency, D the diam. of the wire or rod, and U the wind speed past it. In the present paper a hydraulic experiment is made to test this relation. With values of D equal to 0·5 cm., 0·43 cm. and 0·25 cm. respectively the corresponding mean values of ND/U are 0·192, 0·194 and 0·191, the extreme range of individual determinations being from 0·184 to 0·199. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

133. *Generalisations of Heaviside's Expansion Theorem.* **A. Press.** (Electrician, 83. pp. 449–450, Oct. 17, 1919.)—J. R. Carson [Abs. 1222 (1917)] has established a theorem which appears to include the Heaviside expansion theorem as a particular case. In the present paper it is shown that the original expansion theorem of Heaviside really applies to functions other than the exponential, and, in fact, includes Carson's work. A. W.

134. *Speed of Electric Currents.* **R. A. Fessenden.** (Nature, 103. p. 505, Aug. 28, 1919.)—Refers to F. W. Aston's discovery that the speeds of striæ in capillary tubes of neon or helium are approximately those of sound in these gases, and points out it might throw light on the speed of electricity in wires. E. H. B.

DISCHARGE AND OSCILLATIONS.

135. *Photoelectric and Thermal Electron-Emission.* **A. Becker.** (Ann. d. Physik, 601. pp. 30–54, Sept. 26, 1919.)—A theoretical discussion in which a comparison is made between the photoelectric and thermal emission of ions. An examination is made of the distribution of velocities of electrons produced by these means, and it is shown that the absolute value of the most probable velocity, and hence of all emission velocities, of the electrons liberated from platinum by white light at a certain temperature, is identical with that for the electrons liberated by thermal effects at the same temperature. An exact parallelism is established between photoelectric and thermal electron-emission. A. B. W.

136. *Ionisation of Argon.* **G. Holst and A. N. Koopmans.** (K. Akad. Amsterdam, Proc. 21. 8. pp. 1089–1094, 1919.)—Argon, like other rare gases, does not deprive an electron of much energy by a non-ionising impact with its atoms. By experiments with a plate condenser in various fields the authors show that the ionising potential in argon is 12 volts, and that an electron moving through it loses by impact on an argon atom only 1/750th part of the energy gained between two succeeding impacts. On the other hand, the mean value of the path traversed by an electron with a velocity corresponding to 12 volts is 0·001 cm. The measurements show that all ionisation takes place in a layer of 0·004 cm., so that nearly every impact that can cause ionisation really does cause it. E. E. F.

137. *Hissing Arc.* **E. Bräuer.** (Phys. Zeits. 20. pp. 409–411, Sept. 15, 1919.)—The phenomenon of hissing in the electric arc between carbon or metal electrodes is discussed, and a theory developed to account for the effect, which is apparently due to oscillation between two stable arc conditions. Heat effects play an important part, and at each cycle an acoustic impulse is given to the surrounding atmosphere. With low thermal conductivity of the electrode material, as with carbon, the result

is a hissing note. With higher conductivity the note is often above audible limits. Observations by different workers are in agreement with the theory developed, which requires that the anode current-density should exceed a certain value. This value is given by Ayrton as 70 amps./cm.^{2}, while Luggin [Akad. Wiss. Wien, Ber. 98. p. 1192, 1889] gives the value 50 amps./cm.^{2} Further, the hissing occurs later with greater arc lengths, corresponding to greater heat losses. A. W.

138. *Electric Arc.* **E. Bräuer.** (Ann. d. Physik, 60. 1. pp. 95–108, Sept. 26, 1919.)—Experimental evidence is brought forward to show that in the electric arc the portion of the current due to electrons of thermal origin is only a few per cent. of the total current, and also that the ionic pairs due to impacts by the thermal electrons play no important part in the conduction in the arc, the positive current always being vanishingly small relative to the negative current. A general relation is established between the kathode fall of potential, the current density, and the distance of the kathodic ionising zone from the kathode. This relation is then used to explain the behaviour of the a.c. arc at high frequencies, whose character approximates to that of an ohmic resistance. A. W.

139. *Characteristic Curves of the Glow Discharge.* **G. Valle.** (Akad. Wiss. Wien, Ber. 127. 2a. pp. 1339–1370, 1918.)—The following are the chief points dealt with, the results obtained being given in tabular and graphical form:—Statical and dynamical characteristics and their physical significance; Theoretical view on which with discontinuous discharge of the first kind a certain current-tension curve is to be expected; Current-voltage curves with undoubted discontinuous discharges; Critical considerations on the researches of Riecke, Stark, etc.; Dynamical characteristics. A. E. G.

140. *Nature of the Discharge in Gases at Low Pressures.* **F. W. Aston.** (Roy. Soc., Proc. 96. pp. 200–210, Oct. 9, 1919.)—Experiments are described on the discharge between electrodes of a large flat shape perforated with a long narrow slit, the charge passing through the slit being collected and measured in a Faraday cylinder. Direct measurements made with the Faraday cylinder behind the kathode and at the same potential, seem to indicate that about half the total current in the discharge is brought up to the kathode by positive ions. Attempts to discover the distribution of velocities in this stream show that this is not directly determinable, owing to the very high ionisation in the region of the slit and to other reasons, which are discussed. Using a perforated anode, it was found that, as the distance from the kathode is increased arithmetically, the current carried by the kathode rays into the Faraday cylinder decreases geometrically when the current is constant. The effect of (i) the distance apart of the electrodes and (ii) the total current flowing, on the disappearance of the last trace of the positive column or anode glow, is shown to be remarkably definite, but no adequate explanation of this phenomenon seems available at present. [See Abs. 228 (1913).] A. W.

141. *Investigation of the Induction Coil by means of Röntgen Tubes.* **F. Voltz.** (Phys. Zeits. 20. pp. 412–416, Sept. 15, 1919.)—The induction

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coil dealt with was a symmetrical instrument consisting of two equal separate coils; the primaries of these were connected in series, with a regulating resistance in one connecting lead, and the interrupter (shunted by a lamp and a condenser) in the other. The secondaries were also in series, and between the two on one side was the Röntgen tube, while on the other side were two water resistances with a vacuum spark-gap between. Both primary and secondary circuits were thus quite symmetrical. With this apparatus it is shown by diagrams how, for one and the same tube and tube conditions, the high-potential current curves alter as the capacity across the interrupter is varied, and also how the current-curves differ for different tubes. A parallel is drawn between the decreasing frequencies and the smaller partial discharges with increasing capacity across the interrupter. A. W.

142. *Theory of Vacuum-Tube Amplifiers.* **M. v. Laue.** (Ann. d. Physik, 59. 4. pp. 465–492, Aug. 5, 1919.)—This paper gives a general treatment of the theory of the three-electrode vacuum tube, different formulæ being obtained for the Wien tube, for tubes with a wire as control electrode, and for tubes provided with a grid for control purposes. A. W.

143. *Oscillation Characteristics of Three-Electrode Valves.* **A. Blondel.** (Comptes Rendus, 169. pp. 676–680, Oct. 20, 1919.)—The study of the oscillations generated by three-electrode valves may be carried out in a similar manner to that of the oscillations produced by the singing arc, and oscillation characteristics for the former case may be obtained analogous to those usually employed for the arc. The present paper shows how such oscillation characteristics may be derived, by a graphic transformation of the series of experimental static characteristics connecting the anode voltage with the anode current for different grid voltages. Particular cases are dealt with to illustrate the method of treatment. **Erratum** (*Ibid.* p. 820, Nov. 3, 1919). A. W.

144. *Application of the Thermionic Amplifier to Conductivity Measurements.* **R. E. Hall** and **L. H. Adams.** (Am. Chem. Soc., J. 41. pp. 1515–1525, Oct., 1919.)—The use of an amplifier in conjunction with the telephone in the measurement of the resistance of solutions makes much simpler the determination of the balance position of the bridge. Any ordinary telephone becomes a more sensitive instrument with the amplifier than the best telephones without it. With a sensitive telephone the current through the bridge may be very much reduced, as compared with that required without an amplifier, and the arrangement will still have many times the sensitivity obtained without the amplifier. A valve may be used as a source of alternating current for conductivity measurements and presents many advantages. A first harmonic noticeable at low frequencies is not troublesome at frequencies in conductance measurements beyond audible limits, a telephone can still be employed to indicate the bridge balance by the use of an autodyne method. A. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

145. *Thermoelectric Power and Resistance of Bismuth.* **M. La Rosa.** (N. Cimento, 18. pp. 26–38 and pp. 39–55, July, 1919.)—Starting from the electronic formula for the electric conductivity $\sigma = e^2nvl/(4RT)$,

where n is the number of free electrons per cm.^{3} and l their mean free path, the author calculates the effect produced upon the mean free path by a magnetic field, which gives it a certain curvature. He compares the result with the observed variation of resistance and thermoelectric power in bismuth, and deduces a value $l_0 > 4\times10^{-6}$ for the mean free path of free electrons in Bi at zero field. This is somewhat larger than J. J. Thomson's value deduced from the dimensions of air molecules. Considerations of the density and atomic weight of Bi would give $1{\cdot}2\times10^{-6}$ cm., but this would increase if the Bi atoms were agglomerated into larger groups. [See also Abs. 1324 (1919).] E. E. F.

146. *Thermoelectric Currents in Mercury.* **H. Haga** and **F. Zernike.** (K. Akad. Amsterdam, Proc. 21. 10. pp. 1262–1268, 1919.)—Benedicks has recorded a thermoelectric effect in a homogeneous conductor heated asymmetrically [Abs. 106, 984 (1918)]. The crucial test for the existence of this effect was its detection in the case of a liquid. The result obtained by Benedicks for mercury was vitiated by the conduction of heat along the walls of the containing glass tube. To avoid the effect of the containing tube, the present authors describe an experiment whereby two mercury jets are brought into contact with one another, one being heated and the other at ordinary temperature. The jets were connected to a galvanometer capable of detecting 1/500 microvolt. The fall of temperature at the contact of the jets was estimated at 300 deg. C. over a distance less than 0·1 mm. The galvanometer showed a small steady deflection which changed sign with the reversal of the heating. This e.m.f. is not to be accounted for by any action of the heated mercury on the walls of the delivery tubes, but experiments show that it is due to the existence of a pressure gradient and temperature gradient in one half of the apparatus. An experiment was also made with mercury flowing through a constricted glass tube. To keep the heat conduction along the glass tube small, the sectional area of the walls of the tube was made small in comparison with the cross-section of the mercury column; in addition, the mercury was made to flow towards the heated portion. In this case no thermoelectric effect could be detected. In the opinion of the authors the results of their experiments disprove the existence of the effect as described by Benedicks. L. L.

147. *Thermoelectric Effect in Mercury when Heated Asymmetrically.* **C. Benedicks.** (Comptes Rendus, 169. pp. 578–581, Sept. 29, 1919.)—The author has succeeded in measuring this effect in mercury with a sensitive galvanometer. The influence of the containing walls was avoided [see Abs. 106, 984 (1918)], the constricted channel being drilled in slate. The effect was found to vary as the cube of the temperature-fall and to be of negative sign as theory requires. In the opinion of the author Haga's experiments [see preceding Abs.] with mercury jets do not disprove the existence of the effect. In such an arrangement the surface of contact is necessarily large, also the galvanometer employed by Haga had only 1/5th of the sensibility of that used by the author. The small deflection obtained by Haga when the contact was small is confirmatory evidence of the existence of the effect. L. L.

148. *On the Change of Thermo-Force and of Electrical Conductivity of a Potassium-Sodium Alloy during transition from a Solid to a Liquid State.*

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K. Siebel. (Ann. d. Physik, 60. 3. pp. 260–278, Oct. 20, 1919.)—In a previous investigation [see Abs. 910 (1915)] of a series of pure metals and alloys with respect to their thermoelectric behaviour on fusion, it was shown that, without exception, during transition from solid to liquid and *vice versa*, a more or less abrupt thermal change takes place. From the thermo-curve the change was found to be made up of three distinct phenomena. These are: (1) A curve variation in the vicinity of the fusion point; (2) a change in curve direction at the fusion point; (3) a more or less sudden parallel displacement of one of the branches of the thermo-curve. The two latter phenomena were found to be of a purely thermoelectric character.

The object of the present investigation with a potassium-sodium alloy was to submit the previous results to a further test, and also to find whether a connection exists between the volume-change which takes place on fusion or solidification and the abrupt change in thermo-force and electrical conductivity during the change in the state of aggregation. The properties of the alloy are fully described, and also the difficulties attending its preparation. Section II. deals with the measurement of the thermoelectric force between the Na-K alloy and constantan, and also the determination of the resistivity of the alloy. Experimental details are fully described with diagrams, and tables of results given. The curves for the thermo-force and electrical conductivity are very thoroughly discussed, and similar conclusions derived to those in the previous paper. The paper concludes with a very full theoretical investigation of the subject. H. H. Ho.

149. *Self-Induction of Coils of Rectangular or Square Section.* **I. A. Esau.** (Jahrb. d. Drahtl. Tele. 14. pp. 271–281, Aug., 1919.)—A formula is derived for the self-induction coefficients of coils of rectangular or square winding section. Tables and curves are then obtained which facilitate the self-induction determinations in practical cases. Maximum self-induction for a given length of wire is obtained for coils of square cross-section, when the ratio of winding height to length of side is about 0·4. It has previously been found that the max. self-induction for a given length of wire is obtained, for circular winding section, when the ratio of length to diameter is about 0·4. Measurements of the self-inductance of various coils are in good agreement with theory. All the results in this paper are for close windings. A. W.

150. *Dielectric Constants of Mixtures.* **F. Banneitz.** (Ann. d. Physik, 58, 3. pp. 239–279, July 4, 1919. Dissertation, Leipzig.)—Devises a resonance method of measuring capacities and uses it to determine capacities ranging from 0 to 800 cm. to within 0·2 cm. The dielectric constant of petroleum is shown to be 2·100, within 0·04 %. Mixed bodies are prepared by inserting a number of cylinders at right angles to the field. In one case, cylinders of water (enclosed in glass tubes) are inserted in a three-plate condenser. The theory of Wiener and Rayleigh is confirmed, but only for distances between the cylinders comparable to their diameters. E. E. F.

151. *Colour-Sensitiveness of Photoelectric Cells.* **T. Shinomiya.** (Astrophys. J. 49. pp. 303–310, June, 1919.)—Photoelectric cells were made with kathodes of K, Na and Rb as well as hydrides of the same elements.

The bulbs were 3 to 6 cm. in diam. and the anode rings 1·3 to 3·3 cm. in diam. The cells were filled with argon. The source of light was a 15-amp. gas-filled lamp, and with the aid of a thermopile the photoelectric currents in the various parts of the spectrum were evaluated in amps. per erg/sec. of incident energy. The max. sensitiveness was found in the neighbourhood of 440 $\mu\mu$ in the case of K and Na and their hydrides. In the case of Rb it was at 456 $\mu\mu$, and in Rb-H is was 456. In the case of potassium the maximum was at 437 $\mu\mu$, and the photoelectric current fell to half its max. value at 487 $\mu\mu$ and to ½ at 510 $\mu\mu$. The max. photoelectric current was 3×10^{-8} amp. per erg/sec., with a voltage of 149. The thermo-couple was calibrated by means of a Hefner lamp, which gives 8·3 ergs (total radiation) per sec. per cm.^{2} at 1 m. distance. This flow of energy produced a deflection in the corresponding galvanometer of 154 mm. E. E. F.

152. *Dielectric Constants of some Natural and Synthetic Precious Stones (with Supplementary Note on Amber).* **R. Fellinger.** (Ann. d. Physik. 60. 2. pp. 181–195, Oct. 7, 1919.)—As the results of the experiments here described it is concluded that: (1) The dielectric constants for the natural varieties show a marked difference in the direction parallel and at right angles to the optical axis, which corresponds with the negative double-refraction. (2) The dielectric constants for real ruby and colourless sapphire are not essentially different from one another, and lie in order of magnitude: perpendicular to the optical axis 13, parallel to the optical axis 11. (3) The dielectric constants of the synthetic varieties do not differ essentially nor characteristically from those of the real varieties; it is chiefly noticeable that the dielectric constants in the direction parallel to the optical axis are found to be lower for synthetic than for real crystals. (4) The difference between the dielectric constants perpendicular and parallel to the optical axis for real and synthetic varieties is so much the greater, the more strongly they are coloured.

The following are the dielectric constants obtained:

Topaz, colourless, from Mino, Japan	$\varepsilon_a=6{\cdot}2512$,	$\varepsilon_b=6{\cdot}5357$,	$\varepsilon_c=6{\cdot}4412$
Beryl (aquamarine), from Madagascar	$\varepsilon_\perp=7{\cdot}023$		$\varepsilon_\parallel=6{\cdot}076$
Ruby, from Siam	$\varepsilon_\perp=13{\cdot}2663$		$\varepsilon_\parallel=11{\cdot}284$
Sapphire, colourless, from Ceylon	$\varepsilon_\perp=13{\cdot}186$		$\varepsilon_\parallel=11{\cdot}418$
Synthetic Ruby	$\varepsilon_\perp=13{\cdot}3838$		$\varepsilon_\parallel=11{\cdot}0361$
Synthetic Sapphire, colourless	$\varepsilon_\perp=12{\cdot}80$		$\varepsilon_\parallel=11{\cdot}029$
Amber, gold coloured, North Sea		$\varepsilon=2{\cdot}863$	

A. E. G.

153. *Transmission of Speech by Light.* **A. O. Rankine.** (Phys. Soc., Proc. 31. pp. 242–264; Disc., 264–268, Aug., 1919.)—Speech may be transmitted by photophones in which either the light is affected by speech at the source (microphone and speaking arc) or after it has left the source. A method using the latter alternative has the advantage that sunlight can be employed. The author concentrates the rays from an electric arc or "pointolite" lamp upon a small concave mirror attached to the needle-holder of a gramophone sound-box. After reflection from this mirror, the beam passes through a large long-focus lens which renders it approximately parallel over long distances. Being at the focus, the small mirror exerts no effect upon the divergence of the beam. A "grid"

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of alternately transparent and opaque strips, say 0·1 in. wide, is placed close to the first condensing lens, and the small mirror has a curvature such that an image of this grid is formed on the second or projecting lens. A second grid is made to fit this image and is placed close to the projecting lens so that the luminous strips of the image fall on the opaque strips of the second grid under normal conditions. No light is thus transmitted. But when speech is conveyed to the sounding box (by means of a cardboard trumpet) the vibration of the mirror, amounting to, say, 1/400th of a radian, produces an alternate transmission and stopping of the light in the projected beam. At the receiving end the beam is concentrated by a lens on to a graphite-selenium cell in circuit with 40 volts and a high-resistance telephone receiver. Speech is thus transmitted over at least 1½ miles with a lens of 7 in. aperture at the receiving station, or to greater distances with sunlight. In practice it is found preferable to arrange the grids in such a manner that half the light gets through in a position of rest.—In the *discussion* **W. H. Eccles** mentioned that the speaking-arc method had been used over a distance of 7 km. in Germany, but had the disadvantage of poor articulation. **T. Smith** suggested the use of several receiving sets in parallel, so as to utilise all the transmitted light. E. E. F.

154. *Comparison of Inductances and Capacities by Electrometer Method.* **A. W. Smith.** (Phys. Rev. 14. pp. 356–360, Oct., 1919.)—Describes a method of comparing inductances by means of an electrometer whose quadrants are connected across a condenser in series with the inductance, and whose needle is connected to the middle of a high resistance, shunting the condenser and inductance. It is shown that the deflection of the electrometer is proportional to the inductance, to the square of the current, and inversely proportional to the capacity. The results obtained by the method agree with those obtained with an a.c. bridge. J. W. T. W.

ALTERNATING CURRENTS AND MAGNETISM.

155. *Temperature Coefficient of Permanent Magnet and Shape of Magnet.* **E. Gumlich.** (Ann. d. Physik, 59. 7. pp. 668–688, Sept. 4, 1919. From the Physikal.-Techn. Reichsanstalt.)—The practical importance of the temperature coefficient is evident in the case of the magnet required for a moving-coil instrument; it has been found that magnets containing 1·4 % carbon, although weak, have no temperature coefficient. The effect of shape on the coefficient has already been pointed out by Cancani (1887) and Ashworth (1898). The coefficient itself is small and negative, its value for ordinary materials lying between 2 and 6×10^{-4}. A series of tests was made on cylindrical bars of the same material, of equal diameter but different lengths; for these the coefficient increased as the length diminished. Tests made on ellipsoids gave confirmatory results. In a series of determinations of pole distance it was found that pole distance increased with rise of temperature; also for constant temperature pole distance diminishes slightly with increasing induction until max. permeability is reached; thereafter there is a considerable increase, the poles being almost at the ends of the saturated specimen. The cause of the change in the temperature coefficient does not lie in the change of pole-distance. A small loss of energy was found to be associated with temperature cycles, to which the bar magnets were subjected; after eliminating the permanent change, the graph of deflection and temperature enclosed a small loop, indicating a slight loss of energy. The experiments were extended to horseshoe magnets. G. E. A.

156. *Location of Flaws in Rifle-barrel Steel by Magnetic Analysis.* **R. L. Sanford and W. B. Kouwenhoven.** (Bureau of Standards, Bull. 15. pp. 219–230 [Sci. Papers No. 343], 1919.)—A method was employed to determine the degree of magnetic uniformity along the bars. Barrel forgings were first tested by a point-by-point method [Abs. 551 (1917)], and afterwards by a method similar to that used by Burrows for testing steel rails. A magnetising solenoid surrounds the bar and travels along its length; a test coil is mounted within the solenoid, and is connected to a galvanometer which indicates variations of magnetic flux within the bar. By means of a moving photographic film a permanent record of the motion of the galvanometer spot of light is obtained when the magnetisng coil is run the length of the specimen at uniform speed. Records are given for tests made when strips of transformer iron of various shapes were attached to the bar. Experience of the method gave 15,000 gauss as the best flux density, and the speed of travel adopted was ½ ft./sec.; also a galvanometer period of 1 sec. was found satisfactory. The results obtained showed that the method is amply sensitive to detect and locate flaws. Further study is necessary to determine to what degree the sensitivity of the apparatus should be reduced in order not to cause the rejection of material which is otherwise satisfactory for practical purposes. The greatest difficulty in this line of investigation lies in the interpretation of the results. G. E. A.

157. *Old and New Views of Magnetism at High Frequencies.* **H. Fassbender.** (Jahrb. d. Drahtl. Tele. 14. pp. 222–242, Aug., 1919.)—In 1888, Hertz observed that iron subjected to a h.f. field became only slightly magnetic. This effect was ascribed to the time required to overcome the inertia of the molecular magnets—an assumption which, by itself, was incapable of explaining all the facts. It was next noted that the apparent permeability, for equal frequencies and fields, depended on the sectional area of the specimen; and Zenneck's experiments in 1905 demonstrated the dependence of the magnetic flux on the distribution of the iron; this is now known as the magnetic skin-effect. The most important result of later work confirmed the assumption that the relation between B and H for frequencies up to 10^6 is given by the static magnetisation curve. By means of his experimental results for Heusler alloys under h.f. fields up to 120,000 cycles per sec., the author shows that a correct experimental determination of the induction in ferromagnetic material under such conditions is possible, and gives formulæ for its calculation. Alexanderson has shown that iron can be employed with advantage in h.f. machines up to 200,000 cycles per sec. After citing results by various observers the author points out that research is not keeping pace with practice. In connection with the interesting question of the behaviour of iron in the region of the natural frequency of the iron molecules, it is noted that so far as experiment shows at present, a considerable diminution of the real permeability is to be looked for at very high frequencies. G. E. A.

158. *Magnetic Properties of Rare-Earth Oxides at Low Temperatures.* **E. H. Williams.** (Phys. Rev. 14. pp. 348–351, Oct., 1919. Chem. News, 119. pp. 287–288, Dec. 19, 1919.)—In continuation of previous work [see Abs. 1192 (1919)], to get evidence for or against the magneton theory, observations have been made on rare-earth oxides for temperatures extending down to − 140° C. from room temperature. Tabulated values of χ, the mass susceptibility, are given. With decrease of temperature, this quantity increases in the case of samarium and yttrium oxides, and it is practically constant for lanthanum oxide. The results lead to the conclusion that the quantity θ in $\chi(T + \theta)$ is not a constant, but a function of the temperature. If this is true, Curie's law is followed more closely at low temperatures than at high ones; this is opposite to what Onnes and Perrier found for oxygen. G. E. A.

159. *Magnetic Re-survey of British Isles for Epoch Jan. 1, 1915.* **G. W. Walker** and **A. H. Cox.** (Roy Soc., Phil. Trans. 219. pp. 1–135, Aug. 7, 1919.)—This re-survey was carried out under the auspices of the Royal Society, the Ordnance Survey Office, and the British Association. The same type of apparatus was employed as before, a Kew unifilar magnetometer and a Dover dip-circle. In the field observations, only one distance of deflecting magnet was employed at any station, namely, 25 cm., but, to avoid personal error in setting, fixed geometrical stops were used, and further, the distribution constants were calculated from laboratory measurements made with three distances of the deflecting magnet. The stations were selected and marked permanently by experts from the O.S.O., and these observers also determined the azimuths of suitable reference objects. The scheme was thus linked up with the triangulation of the British Isles, and the magnetic survey is now on a permanent basis. The field work started in March, 1914, and continued till September; it was resumed in April, 1915, and out of about 200 stations 183 were completed. These included the mainlands along with Orkney and Skye, and there were left out 13 stations in the Hebrides, 2 in the Isle of Man, and 6 in the Channel Islands. In reducing the survey, the area was divided into nine districts, and, the magnetic potential at a point having been expressed in terms of the latitude and longitude of the point, a condition was obtained which led to expressions for the north, west, and vertical components of the earth's force in terms of the latitude and longitude. Charts are given of equal values of N, W, and V, and the results are also expressed by means of numerous tables. These results, when compared with those of the previous survey, show a remarkably uniform change all over the British Isles. The changes are smallest along the line Dundee-Stirling-Glasgow-Strachur. Portree is abnormal in the other direction, and at Coleraine the increase in H amounts to 1053 γ. In considering the disturbing forces, three types are taken, and the disturbances in several regions are considered in the light of these types. In concluding, attention is drawn to the enormous advantage which association with the O.S.O. carries; improvement in the scheme for selecting stations is indicated; and the desirability of constructing an instrument for measuring V accurately is put forward. The appendix consists of a report on magnetic disturbances in Northamptonshire and Leicestershire and their relations to geological structure. A detailed magnetic and geological survey of the Melton Mowbray district was made, and the magnetic susceptibilities of the various rocks collected were measured. A series of observations was also made over a large sheet of unworked ferrous carbonate situated near Irthlingborough. G. E. A.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

160. *Perfected Model of Granger Localiser.* **A. Granger.** (Archives d'Él. Médicale, 27. pp. 268–272, Sept., 1919.)—Before the introduction of the present modification it was necessary to watch closely the movements of the shadows of the foreign body and of the indicator, while the tube was being displaced vertically and the indicator was moved vertically. This operation rendered necessary a most attentive observation for several minutes; the causes of error increased quickly with the thickness and area of the region examined. The shadow of the foreign body must also be separated from that of the indicator by about 12 in. The metallic rules which run along the entire length of the baseplate overcome this difficulty. This is the chief point in the new apparatus. The shadows of these rules are easily visible in all positions of the screen; they therefore allow successive measurements to be made of the displacement of the shadow of the foreign body and that of the indicator, for the same displacement of the tube, with rapidity and exactness. A. E. G.

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CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

161. *Elements in order of Atomic Weights.* **R. Szymanowitz.** (Chem. News, 119. pp. 58–59, Aug., 1919.)—On observing certain relationships in the atomic weights of the elements the author arrives at the conclusion that all elements originate from *two* primary substances having atomic weights 1 and 3 respectively. On condensation these substances combine to form, first, helium, and ultimately all the elements with which we are familiar. Hydrogen, of atomic weight one, is assumed as a primary substance, whilst the substance X_3, of atomic weight three, discovered by J. J. Thomson, is the ideal gas to consider as the second true element. The "condensation" of these elementary substances is illustrated from astral spectroscopic evidence. A. B. W.

162. *Thermochemical Examination of the Crystal-Lattice Theory of Born.* **K. Fajans.** (Deutsch. Phys. Gesell., Verh. 21. pp. 539–548, Aug. 30, 1919.)—Born and Landé [Abs. 526 to 531 and 686 (1919)] assume that the Na and Cl′ ions and similar ions occupying alternating corners of the cubes of rocksalt, fluorspar, etc., are held together by electrostatic forces of attraction (decreasing according to Coulomb's law) and by forces of repulsion between the electrons of the exterior shells, decreasing inversely as the 10th power of the distance between the centres of the ions in the case of several alkali salts of known compressibility. The 10 represents the $(n+1)$th power, n representing the number of quanta per electron in the extreme shell. The work to be done for the complete dissociation of a crystal mol into free gaseous ions is numerically equal to the decrease in free energy, which would take place in the formation of a crystal from the ions, $A = (Na/4\delta)(n-1)/n$, where N is $6 \cdot 06 \times 10^{23}$, δ is the lattice constant, and a Madelung's lattice potential of the electron for attraction, the value of which depends merely upon the type of lattice, for alkali halides $a = 13 \cdot 94e^2$, for fluorspar $a = 38 \cdot 7e^2$. The lattice constant δ can be expressed as a function of the crystal density ϱ and the atomic weights μ_+ and μ_- of the ions; thus, according to Born $A = \frac{a}{4(4)^{1/3}} \cdot \frac{(n-1)}{n} \cdot N^{4/3} \cdot \left[\frac{\varrho}{(\mu_+ - \mu_-)}\right]^{1/3}$. Introducing numerical values and expressing the energy in kg. cals., the author finds $A = 545\,[\varrho/(\mu_+ + \mu_-)]^{1/3}$ for alkali halides, and $A = 1514\,[\varrho/(\mu_+ + 2\mu_-)]^{1/3}$ for fluorspar, accepting $n = 9$; for lithium-salts $(n = 2)$ the coefficient would be 490 (not 545). The A values calculated by Born for chlorides, *e.g.* are: LiCl 179, NaCl 182, KCl 163, RbCl 155, $CaCl_2$ 411, on the assumption that the salt formation proceeds according to $(\overset{+}{Li}) + (\overset{-}{Cl}) = [LiCl] + A_{LiCl}$. The author applies these values to some reactions, such as: $2[LiI] + [CaCl_2] = 2[LiCl] + [CaI] + \Delta A$, and to the heat of solution L, which would be, *e.g.* $2[LiI] + Aq = 2\overset{+}{Li}Aq + 2\overset{-}{I}Aq + 2L_{LiI}$. In these formulæ symbols in square brackets designate solid salts, symbols in round brackets gases, and symbols without brackets solutions. The agreement found between the ΔA and ΔL is good in six reactions, like $KCl + LiBr = KBr + LiCl$,

where $\Delta A = 4$ and $\Delta L = 3\cdot 6$. It would thus appear that the heat of reaction between salts can be calculated from Born's formula for the dissociation of the solid salts into free ions; these formulæ contain only the lattice constants and the molecular volume of the crystal (the radicand of the root). It follows further that the n (for which Born calculated values lying between 7·7 and 9·6) must be very nearly as assumed for the halides of K, Na, Ca; for in the case of CaI_2 $n = 8$ would make $\Delta A = 17$, instead of $\Delta A = 12$ calculated and 11·7 found for $n = 9$.
H. B.

163. *Electrical Conductivity conditioned by Isotopes.* **F. H. Loring.** (Chem. News, 119. pp. 62–64, Aug. 8, 1919.)—If the percentages of isotopes, given in a previous paper by the author, be plotted additively with the resistivities a straight-line law is obtained, showing a relation which seems to imply that the theory of whole-number isotopes as applied to the ordinary elements has possibly some foundation in fact. A diagram is now given to illustrate the relation to which reference is made. This diagram is discussed and apparent exceptions to the law are examined.
A. B. W.

164. *Theory of Allotropy, Allotropes and Allotropoids.* **M. Copisarow.** (Chem. News, 118. pp. 265–266, June 6, 1919.)—Allotropy is defined as the capacity of an element to exist in forms differing in the mode of their intramolecular linkage, and must be regarded as a function of valency. It does not imply isomerism or polymerism, as all allotropes need not necessarily contain the same number or a multiple number of atoms in their respective molecules. Valency bonds have a definite direction. From the valency we should be able to indicate the maximum possible number of allotropes and their constitutional formulæ. The valencies may be fixed or free, and this fixation causes the rigidity of the atoms in the molecule. Allotropoids are molecular forms differing in the number of atoms or in the distribution of linkages, but they all belong to the same type of mode of linkage, and serve as a transition link between allotropy and polymorphism. Allotropoids will differ among themselves less than the allotropes of the same element, in physical and chemical properties. The allotropes of metals are more difficult to isolate and to distinguish than those of non-metals.
H. B.

165. *The Reversible Expansion of Refractory Materials.* **H. J. Hodsman** and **J. W. Cobb.** (Chem. News, 119. p. 268, Dec. 5, 1919. Abstract of paper read before the Soc. of Glass Technology, Nov. 19, 1919.)—Silica refractories undergo a permanent expansion on firing, fireclays a permanent contraction. Both show expansion, reversible on cooling, on subsequent heat-treatment. The authors describe the methods they used in studying this reversible expansion between 15° and 1000° C. Aluminium and kaolin expand regularly within this range; silica has about the same mean expansion between 15° and 1000°, but behaves differently at intermediate temperatures, expanding more than kaolin up to 500°, much more again between 500° and 600°, where the α-quartz changes into the β-modification, and expands very little between 600° and 1000°; the change into tridymite was not indicated therefore. A mixture of 80 % of ganister with clay behaved like silica; fireclay and also pot-clay resembled silica more than kaolin, whilst the curves of ball clay, alundum, and carborundum approached the kaolin curves. The bearing of these observations on arching, glass-house pots, etc., is discussed. H. B.

166. *Cellular Solidification.* **C. Dauzère.** (Ann. de Physique, 12. pp. 5–106, July–Aug., 1919.)—The experiments here described were carried out with a view to studying cellular structure in non-living solids (beeswax, phenyl ether, sodium nitrate), and to defining the conditions in which such structure forms at the moment of solidification. Certain observations were made which are connected intimately with the formation of cells. From the results the following conclusions are drawn:—

In all the cases examined cells are produced by the organisation of turbulent movements of the liquid; such movements may exist prior to solidification, or they may be produced in the layer in contact with the solid by the propagation of the solidification itself. The latter case is that encountered with crystallised substances. In a crystal or crystallite exhibiting cells, these are simply the lodgments of small, imperfectly developed crystals, the angles and faces of which have retained the curved form they assumed originally under the combined action of the surface tension and of the previous movements. The formation of cells and the original curved form of the crystalline faces require the presence, at the surface of a growing crystal, of a layer of matter which is not yet quite solid and which may be acted on by surface tensions. This layer is intermediate in condition between the liquid and crystalline solid states and is analogous to Lehmann's liquid crystals. The cells are able to persist only if the substance contains traces of impurities, these collecting at the boundaries of the cells, of which they form the walls.

These conclusions apply not only to the author's observations, but also to those of others, *e.g.* those of Cartaud (1903, 1904) and Robin (1914) on metals. They may, therefore, be regarded as valid for other substances exhibiting analogous phenomena; in particular, they explain the production of the fibrous structure by solidification, each fibre being merely a cell excessively elongated by the regular increase of the solid in depth. T. H. P.

167. *Influence of Hydrogen Sulphide on the Occlusion of Hydrogen by Platinum.* **E. B. Maxted.** (Chem. Soc. J., Trans. 115. pp. 1050–1055, Sept., 1919.)—The apparatus employed consisted of a small glass absorption pipette containing a known weight of palladium-black and connected by means of capillary glass tubing to a Sprengel pump and to a gas burette respectively. The palladium was prepared in the apparatus itself by the reduction of palladium chloride at 100° by means of pure, electrolytic hydrogen. The amount of occlusion which took place in any experiment was determined by measuring the gas evolved when the pipette was evacuated at 100°. A number of concordant experiments showed that 0·6 gm. Pd absorbed about 41 cm.^{3} (N.T.P.) of hydrogen at the ordinary temperature (not stated) and pressure (not stated). Under the same conditions 6·2 cm.^{3} of hydrogen sulphide were absorbed in 1 min., 7·5 cm.^{3} in 10 mins., and 13·5 cm.^{3} after 40 hours. This hydrogen sulphide is not removed to any great extent by exhaustion of the pipette at ordinary temperature, especially when only a small amount has been allowed to be absorbed; on then passing hydrogen into the evacuated pipette occlusion of this gas no longer takes place. It is probable that the minimum volume of hydrogen sulphide, at N.T.P., required for the total inhibition of the hydrogen-occluding properties of 1 gm. of palladium is less than 14 cm.^{3}. When the palladium containing hydrogen sulphide is exhausted at 100° the gas evolved consists almost entirely of hydrogen, and has a volume approximately equal to that of the hydrogen sulphide absorbed. The sulphur remaining behind in the palladium is not sufficient to prevent completely the occlusion of hydrogen. Measurements with palladium of different sulphur-content showed that the mean occlusive power for hydrogen is approximately a linear function of the sulphur content; each atom of sulphur renders almost exactly four Pd atoms incapable of occluding hydrogen, the remainder of the Pd being capable of occluding normally. This may be due to the formation of a compound Pd_4S, but at present the evidence for the existence of such a compound is insufficient. T. S. P.

168. *New Form of Electric Colloid-Synthesis.* **T. Svedberg.** (Nobelinst. Meddel. 5. [Arrhenius Festskrift] (No. 10), pp. 1–18, 1919.)—When the arc is produced between horizontal wire electrodes in an indifferent atmosphere (N, H) and alcohol enters the cooling bulb after extinction of the arc, the alcohol becomes charged with metallic particles. These particles are rather coarse, however, and most of the metal is condensed on the glass walls. The following apparatus was hence adopted. In a vertical quartz tube two wires are fixed in alignment, leaving a gap of about 1 mm. (kathode above) just opposite a small hole in the quartz tube; gas is passed into the quartz tube, which, is surrounded by a wider tube filled with alcohol or other liquids, itself jacketed with water or a cooling mixture. The gas bubbles up through the alcohol, and by a magnetic field the arc is driven through the hole (like the gas) into the liquid. The anode melts (1 or 2 amps. at 220 volts) and seals the lower part of the tube in some cases; various modifications of the apparatus are described. The apparatus is efficient for preparing alcohol sols of silver, gold, copper, lead, etc., even when the liquid is cooled down to − 30° (with copper electrodes). The colour of the sols changes with the conditions. It would appear that there is no spurting of the fused metal, but simply a condensation of metals vaporised by the current heat, and it is the arc itself, not the gas, which carries the vapour into the liquid. For when the hole was small, just allowing the gas to escape while confining the arc (not deflected by the magnetic field), the colloid formation was almost suppressed. The spectrum of the arc shows, according to conditions, the metal lines together with either carbon bands, or merely the nitrogen lines; as the quartz is heated by the arc, a continuous spectrum is sometimes observed, and silica is found in the sols. H. B.

169. *"Regulus" Lead Peroxide.* **W. Palmaer.** (Nobelinst. Meddel. 5. [Arrhenius Festskrift] (No. 31), pp. 1–15, 1919.)—Compact or regulus-like lead peroxide has been prepared, by electrolysis of faintly acid lead nitrate solutions [see Ferchland, Abs. 2306 (1904)], in plates having a thickness of 1 cm. and a length and breadth of 2 cm. In colour and lustre the compact peroxide resembles the metallic modification of selenium, and in general appearance the naturally occurring peroxide, plattnerite. Chemical investigation shows that the total extraneous matter, including water (about 0·07 %) and occluded oxygen, in the product probably

does not exceed 0·5 %. The specific gravity at 18°, referred to water at 4°, is 9·36, the value given by F. W. Clarke ("Constants of Nature," 1888, Part I, p. 47) being 8·91, and that given by Breithaupt for the mineral peroxide, 9·392–9·448. The hardness lies between 5 and 6, that of plattnerite being 5–5·5. The resistivity w_0 is 0·000845 ohm at + 18°, and the specific conductivity, χ, consequently 1180, the product thus occupying a position intermediate to the worst conducting metal (bismuth, χ about 8000) and the best conducting electrolytes, namely, molten salts (χ about 3). The electrical conductivity diminishes by about 10 % for a rise in temperature of 80 deg. T. H. P.

170. *Pyrometer Shortcomings in Glass-house Practice.* **W. M. Clark** and **C. D. Spencer.** (Am. Inst. Mining Eng., Bull. No. 152. pp. 1455–1458, Aug., 1919.)—There are two distinct fields in glass-works for pyro- example, in the case of annealing glassware. The second only demands metry. The first calls for accurate temperature measurement, as, for knowledge of relative comparative fluctuations of temperature. Such would be the case of a glass pot furnace nearly 120 ft. in circumference, where the pyrometer couples only project inside the furnace wall for less than 2 in.; it is inconceivable that these few inches represent the accurate temperature at every point of the circumference, but the relative readings as to whether the pyrometer shows schedule temperature fluctuations are valuable indications for control. The authors lay great stress on the need for standardisation of instruments, and quote the following elements of pyrometer outfits as requiring consideration: (*a*) Thermo-couple wires of different manufacture not interchangeable; (*b*) porcelain tubes not of uniform standard; (*c*) methods of cold-junction compensation not understood; (*d*) indicators and recorders should be reduced to the minimum number of types and standardised.

The great need in glass-works is for a rugged and reliable heat gauge rather than a refined instrument. E. G.

171. *Thermo-couple Installation in Annealing Kilns for Optical Glass.* **E. D. Williamson** and **H. S. Roberts.** (Am. Inst. Mining Eng., Bull. No. 152. pp. 1445–1453, Aug., 1919.)—In the annealing of optical glass, temperatures up to 650° C. have to be measured with an accuracy of better than 5 deg., and with a sensitivity exceeding this; a 10-deg. error will practically double the time necessary for the annealing of the glass. The sensitivity is necessary since the cooling rate must be carefully regulated during the beginning of the cooling. The authors recommend the use of chromel-alumel thermo-elements. They condemn the use of direct-reading millivoltmeters for accurate work, and in their work employed a potentiometer. The leads from the various thermo-elements were brought to a central point for measurement of the thermo-e.m.f. Wiring diagrams are given in the paper showing various alternative schemes. E. G.

172. *Forging Temperatures and Rate of Heating and Cooling of Large Ingots.* **F. E. Bash.** (Am. Inst. Mining Eng., Bull. No. 153. pp. 2869–2880, Sept., 1919.)—Describes experiments on the rate of heating and cooling a 24-in. round ingot under regular production conditions. It is shown that it is possible to heat such an ingot to 1230° C. in 7 hours; the best practice appears to be to heat slowly to the critical temperature and then faster. Low-carbon steels can stand more rapid heating than high-carbon or chromium steels. The outside temperature drops very rapidly in the air and leaves the centre hotter than the outside, this difference being 50 deg. C. for a 24-in. ingot. The temperature gradient from the door to a short distance inside is very large and must create serious stresses at that point. From the rate of cooling it appears such an ingot can be worked for 2 hours without working it too cold. The amount of coal used in the test was 0·25 lb. per lb. of steel, the average amount used for production work at the plant in question being 1 lb. per lb. of steel. C. O. B.

173. *Combination Limits of Silicon with the Iron Metals.* **A. Sanfourche.** (Rev. de Mét. 16. pp. 239–245, July–Aug., 1919.)—Silicon forms a series of compounds with the metals of the iron group, but there is much discordance as to the high-grade Si-alloys. This is only partly due to analytical difficulties. The combination limits, the author finds, vary with the amount of free Si present, and also with the experimental conditions, rate of heating and cooling, etc. In his experiments with Fe, Mn, Co, and Ni, he determines the total Si by dissolving the alloy in fused alkali carbonate, and the free Si by dissolving the alloy (not the free Si in it) in diluted hydrofluoric acid, further determining the metals in the usual ways. The high-grade silicon alloys dissociate at high temperatures, yielding free Si; when an excess of free Si is already present, the compound remains stable; when only enough Si is present to form the compound, a certain proportion is segregated in the dissolved state and the limit of combination is lowered. The limits, upper and lower, correspond to definite compounds only in exceptional cases; the higher limit of iron seems to be $FeSi_2$. H. B.

174. *The Microstructure of very Low Carbon Steel.* **R. E. Bedworth.** (Frank. Inst., J. 188. pp. 407–408, Sept., 1919.)—Very low carbon steel quenched from above the A3 point contains very large quantities of free ferrite, present as needles along the cleavage planes of the austenite. Annealing at temperatures just below A1 for a long period causes Fe_3C to occur as globules. Normalising gives very small grains of pearlite uniformly distributed throughout the ferrite. F. C. T.

175. *Influence of some Elements on the Tenacity of Basic Steel.* **A. McWilliam.** (Iron and Steel Inst., J. 98. pp. 43–55; Disc. and Corres., 56–58, 1918.)—The formula for normalised bars 1 in. in diameter is: Max. stress$=38{,}000+[800+4(C-20)]C+120\ Si+[100+2(C-20)]Mn+1000\ P$ lbs. per sq. in., where C, Si, Mn, and P are the contents of carbon, silicon, manganese, and phosphorus in 0·01 %. F. C. T.

176. *Note on the Liquidus in the Iron-Carbon Diagram.* **G. Cesàro.** (Iron and Steel Inst., J. 99. pp. 447–455; Corres., 456, 1919.)—On examining Carpenter and Keeling's values for the iron-carbon liquidus, either from the point of view of Raoult's law or of the le Chatelier-Schroeder formula, namely, $lz = \varphi/2(1/T_0 - 1/T)$, it is seen that the iron-cementite hypothesis is in better agreement than the iron-carbon theory. The results which best agree support the view that austenite is a solid solution of Fe_3C in Fe_2. F. C. T.

177. *Graphitisation in Iron-Carbon Alloys.* **K. Tawara** and **G. Asahara.** (Iron and Steel Inst., J. 99. pp. 565–580; Corres., 581–584, 1919.)—An investigation of the effect of melting temperatures, casting temperature, and rate of cooling upon the graphitisation of iron-carbon alloys containing 2·95 to 3·92 % carbon and 0·1 % or less Si. Graphitisation appears to be almost entirely due to slow cooling of the water at or near its solidification point. The higher carbon contents tend to precipitate graphite more readily than the lower. It appears that the highest temperature reached by the molten metal is without influence upon the structure. A change in the casting temperature from 1328–1399° C. is also unimportant from the point of view of the structure. At 900° graphitisation did not commence in 7½ hours. The most important factor in producing graphitisation is a slow rate of cooling around and below the solidification temperature. The authors consider that the graphite is formed directly from the liquid phase without the intervention of cementite, and believe further that as a result of the dissociation of Fe_3C free carbon is present in the molten iron. F. C. T.

178. *Quenching of Certain Alloys of Aluminium.* **L. Guillet, J. Durand** and **J. Galibourg.** (Comptes Rendus, 169. pp. 508–511, Sept. 15, 1919.)—The composition of a certain sample of duralumin was: Al 93·9, Cu 3·70, Mn 0·61, Zn 0·25, Mg 0·43, Si 0·58, Fe 0·53 %. The properties in the commercial condition were: Max. stress, 36–40 kg./mm.^{2}; elastic limit, 20–24 kg./mm.^{2}; elongation %, 20–22; reduction of area %, 35–38; shock, 4–55 kg.-m.; Brinell hardness (10-mm. ball and load, 500 kg.), 86–93. As annealed and immediately after quenching from 450° C. the properties are almost identical, as shown below.

	Elastic Limit, kg./mm.^{2}.	Max. Stress, kg. mm.^{2}.	Elongation, %.	Reduction of Area, %.	Shock, kg.-m.	Brinell Hardness.
Annealed	10–14	27–30	20–22	43–45	7–8	63–68
Quenched and at once tested	10–12	25–29	22–23	41–45	8–9	59–67

Shortly after quenching, however, the elastic limit, max. stress and hardness increase, while the elongation and reduction of area fall somewhat. So far no critical point has been allowed. A quenching temperature of about 450° C. is required to show the characteristic increase of hardness. At room temperature a period of 48 hours is sufficient to yield the full hardness after quenching. At liquid-air temperatures the quenched alloy shows a tendency to harden, but as the temperature is raised to 200° C. this becomes more and more rapid, six hours at that temperature producing the hardness obtained in 48 hours at 15° C. Reheating the quenched material to 300° results in a distinct softening. F. C. T.

179. *Effect of Rate of Temperature Change on the Transformations of an Alloy Steel.* **H. Scott.** (Bureau of Standards, Bull. 15. pp. 91–100, [Sci. Paper No. 335], 1919.)—The research deals with a cobalt-chrome steel of the following composition: C, 1·75 %; Mn, 0·26 %; Co, 2·90 %; Cr, 15·0 %. Samples were cooled from a constant temperature of about 900° C. at varying rates. As the rate of cooling is increased the temperature Ar′ gradually falls from 770° to 700°, with a cooling rate of 0·7 deg. C. per sec. The lowered point Ar″ makes its appearance at a cooling velocity of 0·15 deg. per sec., falling from 450° to 380° as the speed of quenching is increased to 1·2 deg. C. per sec. Between the limits 0·15 and 0·7 deg. C. per sec. both Ar′ and Ar″ are found; above the latter limit only Ar″. The heating curves show the Ac1–3 and Ac2 points at fairly constant temperatures, but in the case of a heating curve taken on a sample previously cooled so rapidly as to give the point Ar″ an evolution of heat, Act, is evidenced from 518°–644° C. F. C. T.

180. *Ionic Equilibrium and Contact Potential.* **W. Schottky.** (Deutsch. Phys. Gesell., Verh. 21. pp. 529–532, Aug. 30, 1919.)—A preliminary communication. In spite of experimental failures there must be an evaporation of positive ions from solids, depending only on temperature; but this liberation must be accompanied by the evaporation of a much larger amount of neutral particles such that the "electrochemical equivalent" of the positive ionic current becomes extraordinarily large. The current will only be observable when the ionisation potential of the neutral particles present does not exceed the limit of 10 or 12 volts. In the case of tungsten the negative results of experiments made so far indicate that the ionisation potential of tungsten is greater than 10 volts. The positive particles must have an equilibrium concentration depending upon temperature. Following Laue's electronic-pressure theory, the author makes in his equilibrium equations use of one thermodynamic quantity only, the free energy. He goes further than Laue, by splitting the free energy μ of a charged particle in the solid phase into two components, μ°, the natural free energy, depending merely upon the effect of the immediate surroundings of the particles in the interior of the solid body, and a second term $\nu E(\varphi^\circ - \varphi)$, where ν is the valency, E the charge of a mol. of monovalent positive ions, and φ° and φ are the mean potentials within the solid and at some spot outside it; the latter potential φ is variable with the spot. For two metals the difference $\mu_2^{\circ -} - \mu_1^{\circ -}$ will be the contact potential, and $\mu^\circ - E(\varphi^\circ - \varphi^g)$, where φ^g is the potential in the immediate neighbourhood of the metal, will be the voltaic potential difference. The question as to which particles (electrons, neutral or positive particles) will first be evaporated from a solid will depend upon the minimum absolute value of the μ^-, $\mu^\times$, μ^+; the case that μ^+ should have the smallest value does not, however, appear to occur. The author also substitutes for Richardson's formula of saturation current $i = a\sqrt{(Te^{-b/T})}$, the formula $i = aT^2 e^{\mu^-/RT}$, where a is a numerical constant. Thus the free energy μ^- of the electrons in the solid would directly be determinable from the saturation current, and that would apply also to μ^+. H. B.